UNIVERSITY OF CALIFORNIA

Santa Barbara

Supporting the Literacies and Languages of Science: An Exploration of Preservice Secondary Science Teachers' Language Ideologies and Pedagogical Understandings

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Education

by

Valerie C. Meier

Committee in charge:

Professor Jin Sook Lee, Chair

Professor Julie Bianchini

Professor Diana Arya

December 2023

The dissertation of Valerie Meier is approved.

_____

Diana Arya

_____

Julie Bianchini

_____

Jin Sook Lee, Committee Chair

September 2023

ACKNOWLEDGEMENTS

I would never have finished this dissertation without the help of many people and a few cats. Thank you, Jin Sook, Diana, and Julie, for all of the opportunities you have given me to learn alongside you over the years and for your incredible support in getting me over the finish line. Thank you, mom and dad, for all of your generous support over many, many years. Thank you, Isaac, for tending to the kitties' clamorous, incessant, and occasionally unreasonable demands.

Research supported by NSF grant number: DUE-1557283

VITA OF VALERIE C. MEIER

EDUCATION

Ph.D., Education 2023
Interdisciplinary Emphasis in Applied Linguistics (expected)

MA, Second Language Studies 2013
University of Hawai‘i at Mānoa, HI

MA (with distinction), English Composition 2003
San Francisco State University, CA

BA (*cum laude*), English Literature 1998
Tufts University, MA

BFA, Studio Art 1998
School of the Museum of Fine Arts Boston, MA

HONORS AND AWARDS

Carol Genetti Graduate Mentoring Award, University of California Santa Barbara, 2021

Chun and Polchinski Applied Linguistics Fellowship, UCSB, 2020

Graduate Student Award, American Association of Applied Linguistics, 2020

Excellence in Teaching and Mentoring, Gevirtz Graduate School of Education, UCSB, 2018

PUBLICATIONS

Harris, S., **Meier**, V. & Arya, D.J. (in press). Reconstructing the *academic* in academic language: Radically listening to hidden worlds of knowledge building. In A. Tomlin and O. Silverman Andrews (Eds.), *When we hear them: Attuning teachers to language diverse students*. Information Age Publishing.

Lee, J.S, **Meier**, V., Harris, S., Bucholtz, M., & Casillas, D.I. (2020). School Kids Investigating Language in Life and Society: Growing pains in creating dialogic learning opportunities. In Kibler, A., Valdéz, G., & Walqui, A. (Eds.) Reconceptualizing the role of critical dialogue in American classrooms. Routledge.

Meier, V., Aminger, W., McLean, M., Carpenter, S., Moon, S., Hough, S., & Bianchini, J. (2020). Preservice secondary science teachers' understanding of academic language: Moving beyond "just the vocabulary." *Science Education, 104*, 222-251. http://dx.doi.org/10.1002/sce.21560

Arya, D., Swami, S. & **Meier**, V. (2018). Reading comprehension assessment. In B. Frey (Ed.) *The SAGE encyclopedia of educational research, measurement, and evaluation.* Sage Publications. http://dx.doi.org/10.4135/9781506326139.n580

Meier, V., Trace, J., & Janssen, G. (2016). The rating scale in writing assessment. In J. Banerjee & D. Tsagari (Eds.) *Contemporary second language assessment* (165-188). Continuum.

Trace, J., **Meier**, V., & Janssen, G. (2016). "I can see that": Developing shared rubric category interpretations through score negotiation. *Assessing Writing, 30,* 32-43. doi:10.1016/j.asw.2016.08.001

Janssen, G., **Meier**, V., & Trace, J. (2015). Building a better rubric: Mixed methods rubric revision. *Assessing Writing, 26,* 51-66. doi:10.1016/j.asw.2015.07.002

Trace, J., Janssen, G., & **Meier**, V. (2015). Measuring the impact of rater negotiation in writing performance assessment. *Language Testing.* doi:10.1177/0265532215594830

Janssen, G., **Meier**, V. , and Trace, J. (2014). Classical test theory and item response theory: Two understandings of one high-stakes performance exam. *Colombian Applied Linguistics Journal*, *16*(2), 167-184. http://www.scielo.org.co/pdf/calj/v16n2/v16n2a04.pdf

Janssen, G., & **Meier**, V. (2013). Establishing placement test fit and performance: Serving local needs. *Colombian Applied Linguistics Journal, 15*(1), 100–113. http://www.scielo.org.co/pdf/calj/v15n1/v15n1a7.pdf

PEER REVIEWED CONFERENCE PRESENTATIONS

Meier, V., Bennett, M., Galisky, J., Bianchini, J. (2022, March). *How preservice secondary science teachers support scientific sensemaking and discourse across disciplines.* [Paper Presentation]. National Association for Research in Science Teaching, Vancouver, BC, Canada.

Meier, V. (2020, March). *Coordinating planned and interactional scaffolding to engage multilingual learners in scientific discourse* [Paper Presentation]. American Association of Applied Linguistics Annual Meeting, Denver, CO. (Conference Canceled)

Harris, S., **Meier**, V. & Lee, J. (2020, April) *Creating affordances for multilingual learners as agents of sociolinguistic justice* [Symposium]. American Educational Research Association Annual Meeting, San Francisco, CA. http://tinyurl.com/qkcydnn (Conference Canceled)

Spina, A. D., **Meier**, V. & Bianchini, J. (2020, April) *Preservice secondary science and mathematics teachers' understanding of how to teach English learners: A comparison across programs* [Roundtable Session]. American Educational Research Association Annual Meeting, San Francisco, CA. http://tinyurl.com/qrhrf42 (Conference Canceled)

Meier, V., Spina, A., McLean, M., Aminger, W., Carpenter, S. and Bianchini, J. (2019, April). *Investigating preservice secondary science and mathematics teachers' understanding of English learners*. [Paper Presentation]. American Educational Research Association Annual Meeting, Toronto, ON, Canada.

Meier, V., Spina, A., McLean, M., Aminger, W., Carpenter, S. and Bianchini, J. (2019, March). *Preservice secondary science and mathematics teachers' understanding of English learners* [Paper Presentation]. American Association of Applied Linguistics Annual Meeting, Atlanta, GA.

Lee, J. S., **Meier**, V., and Harris, S. (2019, March). *Creating opportunities for English language learners to become agents of sociolinguistic justice* [Paper Presentation]. American Association of Applied Linguistics Annual Meeting, Atlanta, GA.

Meier, V., Aminger, W., McLean, M., Hough, S. and Bianchini, J. (2018, April). *How do preservice secondary science teachers support discourse for English learners*? [Paper Presentation]. American Educational Research Association Annual Meeting, New York, NY.

Meier, V., Lee, J.S., Aminger, W. McLean, M., Hough, S. and Bianchini, J. (2018, March). *"Evidence of language understanding and use": A study of preservice secondary science teachers* [Paper Presentation]. American Association of Applied Linguistics Annual Meeting, Chicago, IL.

Meier, V., Lee, J.S., Aminger, W., Carpenter, S., Hough, S., Iveland, A., Moon, S., & Bianchini, J. (2017, April). *Developing a practice-grounded understanding of academic language: An investigation of preservice science teachers* [Paper Presentation]. American Educational Research Association Annual Meeting, San Antonio, TX.

Janssen, G., **Meier**, V., Restrepo, S., & Danies, G. (2016, April). *Addressing the demands of global academic publishing: One Colombian university's response* [Symposium]. American Association of Applied Linguistics Annual Meeting, Orlando, Florida.

Meier, V. and Trace, J. (2013, May) *Critical thinking in online discussions: The importance of task design and social presence* [Paper Presentation]. Computer Assisted Language Instruction Colloquium Conference, Honolulu, HI.

RESEARCH EXPERIENCE

Graduate Student Researcher, University of California Santa Barbara 2016–2023
NSF Projects: The Science and Mathematics Teacher Research Initiative (SMTRI) and STEM Teachers for English Language Learners: Excellence and Retention (STELLER) (PI Julie Bianchini)

TEACHING EXPERIENCE

Instructor of Record Positions

Graduate Teaching Associate, Department of Education, University of California Santa Barbara — 2016–2021
Course: ED 123: Culture, Development, and Education

Instructor, Multiple Subject Credential Program, Antioch University Santa Barbara — 2015–2019
Course: HDV4581: Language Development and Acquisition

Graduate Teaching Associate, English Language Institute, University of Hawai‘i at Mānoa — 2011-2012
Courses: ELI 83:Writing for International Graduate Students
ELI 82: Advanced ESL Reading

Instructor, English Department, San Francisco State University — 2005–2007
Courses: ENG 114: First Year Written Composition
ENG 48/51: Introduction to College Writing I and II
ENG 118/121: Effective College Reading I and II

Instructor, English Department, Skyline Community College — 2006
Course: READ 826: Reading Improvement

Graduate Teaching Associate, English Department, San Francisco State University — 2001–2003
Courses: ENG 114: First Year Written Composition
ENG 414: Elements of Writing

Other Positions

Teaching Assistant, Department of Education, University of California Santa Barbara — Fall 2014, Spring 2015, Fall 2020, Fall 2021, Spring 2023
Courses: ED 123: Culture, Development, and Education
ED 139: Community-Based Coastal Literacies

PROGRAM ADMINISTRATION

Professional Development Director, McEnroe Reading & Language Arts Clinic, Gevirtz Graduate School of Education, UCSB — 2023

Program Manager, School Kids Investigating Language in Life and Society (SKILLS), UCSB	2021–2022
Coordinator, Community Based Coastal Literacies, Gevirtz Graduate School of Education, UCSB	2019–2022
Coordinator, Family Services, McEnroe Reading & Language Arts Clinic, Gevirtz Graduate School of Education, UCSB	2015–2019
Coordinator, School Kids Investigating Language in Life and Society (SKILLS), UCSB	2018–2019 2015–2017

COMMUNITY SERVICE

UCSB Team Member, Multi-Lingual Students Networked Improvement Community, California Teacher Education Research and Improvement Network	2019–2021
Instructor, School Kids Investigating Language in Life and Society (SKILLS), UCSB	2017–2022

PROFESSIONAL MEMBERSHIPS

American Association of Applied Linguistic

American Educational Research Association

ABSTRACT

Supporting the Literacies and Languages of Science:

An Exploration of Preservice Secondary Science Teachers'

Language Ideologies and Pedagogical Understandings

by

Valerie C. Meier

Given the increasing number of multilingual learners enrolled in U.S. secondary schools and persistent disparities in access to quality STEM education for these students, teacher education programs must prepare secondary science teachers capable of teaching multilingual learners in equitable ways. There is a consensus in science education scholarship that as part of this preparation, preservice secondary science teachers should learn to support the literacies and languages of science so that multilingual learners can engage in meaningful disciplinary sensemaking and discourse practices. However, this scholarship has paid less attention to the ways in which preservice science teachers' understandings of effective literacy and language support are mediated by their language ideologies. Without scrupulous attention to language ideologies, even well-intentioned efforts to support multilingual learners can reproduce linguistic hierarchies that privilege the languages and language practices of educated, white, middle-class, monolingual English speakers and further stigmatize the languages and language practices of multilingual and/or racialized students. In order to disrupt harmful language ideologies, secondary science teachers must be able to

reflect critically on the opportunities they create for students to engage in the literacies and languages of science and the ways in which they support this engagement.

In this qualitative study, I explored the connections across preservice secondary science teachers' language ideologies, understandings of language support, and capacities for (critical) reflection. To do so, I analyzed interview data collected from 26 preservice secondary science teachers enrolled in a teacher education program with an explicit focus on preparing teachers to work with multilingual learners. I found that participants' understandings of how to support the literacies and languages of science were shaped by language ideologies related to bi/multilingualism, academic language, and scientific literacies. Participants' understandings of effective literacy and language support for multilingual learners were constrained by monoglossic language ideologies and their uncritical acceptance of "academic language" and other constructs related to simplistic, structural views of language. At the same time, participants understood oral and written discourse to be central to science learning and often reported supporting scientific literacies in ways that foregrounded students' abilities to engage in disciplinary sense-making and communication practices rather than simply reproduce linguistic forms. It was much more common for participants to reflect on their own and their students' challenges with scientific literacies than for participants to reflect on beliefs or practices related multilingualism or academic language, and yet few participants engaged in any *critical* reflection.

Based on these findings, I argue that teacher education programs must be more intentional about creating both ideological spaces and implementational spaces for heteroglossic understandings of bi/multilingualism (Flores & Schissel, 2014) and adopt a sociolinguistically-informed approach to disciplinary language. At the same time, teacher

education programs should meaningfully engage preservice secondary science teachers in critical reflection on their beliefs about language so that they develop the ability to surface, interrogate, and disrupt any language ideologies that might further marginalize their multilingual learners and perpetuate linguistic hierarchies.

TABLE OF CONTENTS

I. Introduction

Over the past decade, three converging factors—the language-intensive nature of the *Next Generation Science Standards* (Lee, Quinn, Valdés, 2013), the increasing number of multilingual learners[1] enrolled in U.S. secondary schools (Irwin et al., 2022), and the persistent disparities in access to quality STEM education for multilingual learners (National Academies of Sciences, Engineering, and Medicine, 2018)—have underscored the need to improve scholarship and practice around preparing linguistically responsive science teachers. Addressing this need, researchers have proposed instructional frameworks that detail the essential components of effective science instruction for multilingual learners; examples of frameworks used specifically in secondary science teacher education include the Secondary Science Teaching with English Language and Literacy Acquisition framework (SSTELLA), described in Lyon et al. 2018; the principles for effective multilingual learner instruction, described in Meier et al., 2020; and the Teaching English Learners Language- and Literacy-Integrated Science framework (TELLIS), described in Rutt and Mumba, 2020. All these frameworks presuppose that language development is a product of rather than a prerequisite to meaningful science learning and that multilingual learners are fully capable of participating successfully in mainstream science classrooms. They share a number of additional elements, including their emphasis on contextualizing science instruction in ways that leverage multilingual learners' cultural, linguistic, and experiential funds of knowledge; their focus on engaging multilingual learners in disciplinary sense-making practices

[1] I use the term multilingual learners to describe students who are institutionally classified as English Learners as well as students who have been reclassified; though this term is not typically used in schools, it has become common in research that seeks to emphasize these students' linguistic assets. My participants use the term English Learner, the term more commonly used in schools and the one used in the interview questions.

alongside written, oral, and multimodal disciplinary discourses; and their attention to providing multilingual learners with appropriate language and literacy support.

Because contextualizing science instruction and engaging students in authentic disciplinary practices and discourses are key principles of contemporary approaches to science for all students (NGSS Lead States, 2013; Windschitl et al., 2018), it is the provision of language support specifically intended for multilingual students that differentiates these frameworks from "just good teaching" (de Jong & Harper, 2005). While they vary somewhat in scope and emphasis, these frameworks all assume that effective science teachers need to be able to identify the language demands of their lessons, anticipate potential challenges, and provide multilingual learners with relevant support. The assumption that teachers must be able to recognize and support the specific language challenges associated with their content area is echoed in constructs such as pedagogical language knowledge (Bunch, 2013) and disciplinary linguistic knowledge (Turkan et al., 2014), both of which address the specialized knowledge of language and literacy that mainstream content-area teachers should develop in order to support multilingual learners to engage in disciplinary learning. Although providing multilingual learners language support seems commonsensical, this process is not a neutral enterprise. Identifying and supporting language demands involves, at a minimum, tacit or explicit judgements about which language varieties, forms, and practices teachers consider useful and appropriate for learning. In other words, teachers' instructional decisions around how to scaffold language are deeply informed by their language ideologies.

Language ideologies are "morally and politically loaded representations of the nature, structure, and use of languages in a social world" that encompass not just mental constructs and beliefs but also practices (Woolard, 2021, p. 1). Language ideologies are freighted with

moral and political significance because they "endow some linguistic features or varieties with greater value than others, for some circumstances and some speakers" and consequently "turn some participants' practices into symbolic capital that brings social and economic rewards" (Woolard, 2021, p. 2). In typical U.S. classrooms, common language ideologies include privileging English over other named national languages (Hinton, 2016); privileging Dominant American English (i.e., what is often called "standard" English) over Black Language (Baker-Bell, 2020); privileging linguistic features and practices construed as "academic" over those considered informal or conversational (García & Solorza, 2021; Valdés, 2017); and privileging monolingual language practices over bilingual language practices such as translanguaging (Flores & Schissel, 2014). A consequence of these ideologies is that the language practices of educated, white, middle-class, monolingual English speakers accrue symbolic capital in school settings while the languages and language practices of multilingual and/or racialized students are further stigmatized.

Without a critical sociolinguistic consciousness—an awareness of the sociopolitical context and consequences of language variation and use—teachers will tend to look for technical solutions to systemic inequalities that cannot be dismantled through methods alone (Bartolomé, 1994). For this reason, cultivating the ability to engage in critical reflection is a key component of preparing teachers to teach multilingual learners in equitable ways. Critical reflection goes beyond considering one's own teaching practice and entails "analyzing, questioning, and critiquing established assumptions of oneself, schools, and the society about teaching and learning, and the social and political implications of schooling" (Liu, 2015, p. 144). That is, critical reflection asks teachers to reflect on how their actions and decisions shape not just their students' content learning but also broader social justice

goals. In the case of language ideologies specifically, critical reflection invites teachers to assess their teaching practice in light of the kinds of linguistic hierarchies described in the previous paragraph and to take action to disrupt these hierarchies. In this way, teachers can begin to reach beyond equity as *access* to "the knowledge, practices, and language normatively valued in schools" and work towards equity as *transformation* of "the knowledge, practices, and language valued in schools in ways that center minoritized students and their communities" (Grapin, 2023, p. 1000).

Exploring the connections across language ideologies, critical reflection, and preservice teachers' understanding of how to support language for their multilingual learners, I address an important gap in the literature on the preparation of secondary science teachers for multilingual learners. Recently, researchers have begun to document how preservice and beginning teachers support language in secondary science classrooms (Heineke et al., 2019; Lyon et al., 2018; Meier et al., 2020; Rutt & Mumba, 2020, 2022, 2023; Smetana et al. 2020). At the same time, researchers have focused on elucidating prospective, preservice, and in-service teachers' language ideologies (Athanases et al., 2019; Bacon, 2018; Kaveh, 2022; Kibler et al., 2023; Lindahl et al., 2021). However, I am aware of only study (Lemmi et al., 2019) that has investigated the language ideologies of secondary science teachers.

In this study, I couple an analysis of preservice secondary science teachers' explicitly articulated beliefs about students' language learning needs and abilities with an examination of what they understand to be effective language support. At the same time, I also document the ways in which secondary science teachers critically reflect on these beliefs and understandings. To answer my overarching question—What were preservice secondary

science teachers' understandings of how to support the languages and literacies of science for multilingual learners?— I address the following research questions:

1. What language ideologies were manifest in teachers' approaches to supporting the literacies and languages of science?
2. What did teachers understand to be effective support for engaging students in the literacies and languages of science? What differences, if any, were there between their understanding of effective support for multilingual learners and for students in general?
3. In what ways, if any, did teachers engage in critical reflection on their language ideologies and understanding of effective support?

To answer these research questions, I use interview data collected from 26 preservice secondary science teachers enrolled in a teacher education program with an explicit focus on preparing teachers to work with multilingual learners.

In the following chapters I review the literature on preservice secondary science teachers' support for the languages and literatures of science and elaborate on my conceptual framework (Chapter 2); describe my methods (Chapter 3); present findings (Chapter 4); and synthesize these findings in order to highlight the implications of this research for policy, practice, and future scholarship (Chapter 5).

II. Conceptual Framework

Literature Review

Over the past several years, there has been a steady growth in research on preservice secondary science teachers' understanding of and/or practices for supporting the literacies and languages of science. Here I review only those studies that investigated preservice secondary science teachers who, through their teacher education programs, learned to teach multilingual learners using a principled instructional framework for integrating language and science instruction.

One influential instructional framework, introduced by Tolbert et al. (2014) and refined by Lyon et al. (2018), is the Secondary Science Teaching with English Language and Literacy Acquisition (SSTELLA) framework. The SSTELLA framework was designed to emphasize the "reciprocal and synergistic relationship between language, literacy, and science" by integrating attention to (a) scientific sense-making, (b) scientific (oral) discourse, (c) language and disciplinary literacy, and (d) contextualized science activity (Lyon et al., 2018, p. 26). Each of these four dimensions was associated with two (or, in one case, three) instructional practices, for a total of nine core SSTELLA practices considered critical for effectively teaching multilingual learners. Although this framework foregrounded the importance of both oral interaction and disciplinary literacies, it conceptualized "language" rather narrowly in terms of vocabulary development. And while the two practices related to contextualizing science activity asked teachers to be responsive to students' experiential funds of knowledge, none of the practices addressed using multilingual learners' linguistic repertoires or home language(s).

Lyon et al. (2018) collaborated with four science methods instructors participating in six different teacher education programs across three states to redesign their science methods courses in alignment with the SSTELLA framework. They then used a classroom observation rubric to assess the level at which 82 preservice secondary science teachers enrolled in the redesigned courses enacted the nine SSTELLA practices and compared these participants' scores to the scores of a baseline group of 48 participants who had taken the methods courses prior to the redesign. Most relevant to the present study, Lyon et al. (2018) found that although there was variation across programs, the redesigned methods courses were associated with positive changes in two of the SSTELLA practices: creating opportunities for student interaction and facilitating productive science talk. They concluded that a principled instructional framework such as SSTELLA can shift preservice secondary science teachers' understanding of how to support multilingual learners, encouraging them to meaningful integrate language use with disciplinary sense-making rather than simply supplementing traditional instruction with supports such as visuals or front-loaded vocabulary.

Rutt and Mumba (2020, 2022, 2023) conducted a series of studies investigating the ways in which preservice secondary science teachers implemented the principles of the Teaching English Learners Language- and Literacy-Integrated Science (TELLIS) instructional framework in their planning and/or instruction for multilingual learners. The TELLIS framework, which was based in part on the SSTELLA framework, included five foci —integrating (a) oral discourse, (b) literacy development, (c) language scaffolding, (d) contextualized science learning, and (e) students' own multilingualism—embedded within the larger goal of engaging students in standards-aligned science and engineering practices.

In their first study, Rutt and Mumba (2020) investigated whether and how 11 preservice secondary science teachers adjusted their planning for language- and literacy-integrated science instruction after participating in two science methods courses that emphasized the TELLIS instructional framework (the "intervention"). They found that in the post-intervention lesson plans, participants included more opportunities for oral discourse in the form of small group and partner activities, more writing activities that simultaneously engaged students in one of the eight NGSS science and engineering practices, and a broader range of language supports. However, they did not find similar growth in participants' ability to contextualize science instruction in students' specific experiential or cultural funds of knowledge. And while more participants incorporated the principle *using students' multilingualism as an instructional support* in their post-intervention lesson plans (approximately half of participants in the post-intervention lesson plans, compared to only participant in the pre-intervention lesson plans), this was the least consistently implemented TELLIS practice. Rutt and Mumba tentatively concluded that science methods courses which systematically integrate attention to language and literacy are likely to be more effective at preparing secondary science teachers to teach multilingual learners than stand-alone classes. While they recognized participants' challenges in using students' multilingual repertoires, in this paper Rutt and Mumba did not connect these challenges to monolingual language ideologies.

In a subsequent study, Rutt and Mumba (2022), examined the degree to which three secondary science teachers were able to implement the TELLIS instructional principles in the four-day lesson cycles they submitted for the TPA, a high-stakes performance assessment used for initial teacher credentialling. In terms of strengths, they found that participants

engaged their students in science and engineering practices and contextualized their instruction in students' experiences, albeit in more general ways. In terms of challenges, they found that participants varied in their ability to incorporate oral discourse and literacy opportunities and that all three participants employed more strategies for helping multilingual learners interpret language than to produce language. They also found that only one of the three participants implemented the principle *using students' multilingualism as an instructional support.* Rutt and Mumba (2022) concluded that the cognitive apprenticeship model, implemented over two language- and literacy-integrated science teaching methods courses, was largely successful in preparing participants to implement TELLIS practices in their student teaching placements, but that participants' challenges warranted revisions to the teacher education coursework, including more attention to supporting language production and translanguaging pedagogies. In this study, Rutt and Mumba (2022) briefly explore the role of monolingual language ideologies in shaping participants decisions to (not) use students' multilingualism, a finding which they explored in more detail in the study described below.

In a later study, Rutt and Mumba (2023) drew on the same case studies examined in Rutt and Mumba (2022) but interpreted this data through the lens of Cultural-Historical Activity Theory. Among other findings, their analysis revealed that key components of the activity system—particularly the student community and school-wide monolingual norms—mediated their three participants' implementation of the TELLIS practice *using students' multilingualism as an instructional support*. Although in their interviews all three preservice teachers and their mentor teachers recognized that teachers' and students' multilingualism could be a resource for teaching multilingual learners, these beliefs did not consistently

translate into practice. While one bilingual participant pushed back on her students' initial reluctance to use Spanish and regularly incorporated Spanish in her students teaching and TPA lesson cycle, the other bilingual participant readily acquiesced to her students' preference for only using English. The third participant, who identified as monolingual, also did not attempt to integrate students' multilingualism. The authors conjectured that entrenched monolingual language ideologies in both the local school contexts and society more generally could have accounted for students' aversion to using Spanish and two participants' decision not to confront the monolingual status quo in their classrooms, despite what they were learning in their teacher education program.

A final study was conducted in the same context as the current study, a teacher education program which at the time employed an instructional framework consisting of four principles for effective multilingual learner instruction: engaging students in cognitively demanding tasks, drawing on students' funds of knowledge, providing students rich opportunities for language use, and identifying and supporting academic language demands. Meier et al. (2020) investigated changes in seven preservice secondary science teachers' understanding of academic language and the strategies they reported using to support academic language at the level vocabulary, syntax, and discourse over the course of their teacher education program. They found that by the end of their teacher education program, participants understood academic language to comprise more than just vocabulary and viewed academic language as an integral part of science learning. They also documented growth in the range of strategies participants used to support academic language demands at the lexical, syntactic, and discourse levels. Meier et al. (2020) cautioned than in supporting students to "interpret and produce academic language, it is crucial that [teachers] do so in

ways that also recognize, validate, and leverage students' existing languages and linguistic practices" (p. 226). However, they did not examine the ways in which participants' understandings of academic language shaped their perceptions of "non-academic" language or participants' openness to incorporating a wide variety of language varieties and practices in their classrooms. In other words, they did not examine the consequences of participants' academic language ideologies.

In sum, the research described above was grounded in principled instructional frameworks that shared an emphasis on providing multilingual learners meaningful opportunities to use oral and written discourse as they engaged in science and engineering practices. This research also highlighted the need to scaffold the language and literacy demands in science classrooms. However, none of these studies—either in the instructional frameworks used to prepare preservice secondary science teacher participants or in the conceptual frameworks used to interpret results—incorporated sustained attention to language ideologies, though Rutt & Mumba (2023) did address monolingual language ideologies in their discussion.

One final study is worth noting because it was, at the time I conducted my literature review, the only example I could find of research that focused specifically on secondary science teachers' language ideologies. Lemmi et al. (2019) used focus group data to examine the language ideologies of 19 in-service secondary science teachers who taught courses that included students who were bureaucratically classified as English learners. Across participants' discussions, they found evidence of both language-exclusive and language-inclusive ideologies. When participants expressed language-exclusive ideologies, they implied that some language forms—for example, scientific terminology or standardized

language—were more suitable for scientific communication because they met participants' expectations for clarity, appropriateness, and formality. Lemmi et al. explain that it was "rare for teachers to report excluding specific linguistic forms from their practice" but that these participants' "ideological approach was implicitly exclusive in that it valued how students express scientific ideas over the substance of what they actually say or write" (p. 867). In contrast, participants expressing language-inclusive ideologies foregrounded students' scientific understandings over the linguistic forms they used to communicate these understandings. Lemmi et al. found that most participants held both sets of ideologies. While they cautioned against assuming either ideology was inherently good or bad, Lemmi et al. did conclude that language-inclusive pedagogies which incorporate the full range of students' languages and dialects have the potential to nurture a greater sense of belonging for language minoritized students.

Conceptual Framework

In order to disrupt harmful language ideologies, secondary science teachers must be able to reflect critically on the opportunities they create for students to engage in the literacies and languages of science and the ways in which they support this engagement. In this chapter I first argue for an expansive definition of the literacies and languages of science, one that accounts for the ways that language is actually used to construct and communicate knowledge in the domain of professional science and that creates space for students to draw on their full linguistic repertoire as they learn to think and communicate in scientifically valued ways. I also argue for a principled approach to supporting the literacies and languages of science that goes beyond attention to linguistic forms. Next, I more fully describe how attending to teachers' language ideologies can reveal tacit orientations to language users that

can distort even well-intentioned efforts to provide multilingual learners with equitable learning opportunities. Finally, I argue for the importance of developing teachers' capacity for critical reflection as way to surface and interrogate these language ideologies.

The Literacies and Languages of Science

In examining participants' understanding of effective language support, I am guided by contemporary understandings which foreground language-in-use—the view of "language as a set of meaning-making practices learned through participation in social practices" (Lee et al., 2019, p. 319)—over traditional views of language as a self-contained system of linguistic structures. In the following sections, I argue that an interdisciplinary body of research warrants an expansive definition of the literacies and languages of science and that an understanding of effective literacy and language support must transcends mere attention to linguistic form.

Defining the Literacies and Languages of Science. Below I first define my view of scientific language at the level of discourse (the literacies of science) and then at a more granular level, in terms of registers (the languages of science). While the distinction is somewhat arbitrary and reflects a structural view of language, it is nonetheless useful to temporarily separate the two in order to consider the different bodies of literature underpinning each.

***The Literacies of Science*.** The interdisciplinary body of anthropological, historical, philosophical, and sociological research known as the social studies of science has established a robust body of empirical evidence detailing how scientific knowledge is constructed within disciplinary communities. Unlike positivist narratives which depict science as the objective and unproblematic discovery and presentation of facts already

existing in nature, research in this tradition describes how professional scientists develop disciplinary ways of perceiving, reasoning about, and representing the natural world which are grounded in socially and historically situated norms and values. In a laboratory or in the field, scientists draw on material practices for constructing new knowledge claims and then, via academic journals, conferences, and other public forums, they engage in social practices for promoting, contesting, and accepting such claims (Bazerman, 1988; Ford & Forman, 2006; Ford, 2008; Latour, 1999). Discourse mediates all this epistemic activity, as scientists use language and other semiotic systems (e.g., visual and mathematical) to frame, observe, measure, model, quantify, display, describe, explain, conjecture, claim, justify, defend, and critique (Lemke, 2004).

Consequently, I understand the literacies of a secondary science classroom to encompass not just reading and writing but all the ways students use oral and written language and other modes of communication (e.g., visual or gestural) as they participate in practices of scientific investigation, sense-making, and communication. Practically speaking, this typically involves the eight science and engineering practices outlined in the Next Generation Science Standards: Students engage in scientific literacies any time they wonder and pose empirical questions about the natural world; collaboratively design investigations and interpret data; develop, revise, and reason with scientific models; advance and critique evidence-based arguments; construct how and why explanations of natural phenomenon; and communicate their understandings to others through a variety of multimodal texts.

The Languages of Science. The technical, dense, and impersonal nature of the language forms students encounter science classrooms is well-attested, both in the literature describing the characteristic features of written science texts (Fang, 2005; Fang et al., 2006;

Snow, 2010) and in students' own perceptions of science as employing rigorous and at times intimidating language forms (Brown, 2005). One approach to defining the language of science, then, is to focus on those linguistic features that are assumed to be both most distinctive and least familiar to students (Schelppegrell, 2004). Importantly, many researchers advocating this approach are grounded in the tradition of systemic functional linguistics, which has examined how Western scientists use specific lexical, grammatical, and discursive features to construe the natural world in a way that serves their epistemic and communicative needs (Halliday, 1993). That is, this tradition is deeply concerned with language use, not decontextualized linguistic forms.

Nonetheless, there are several key problems with assuming that descriptions of scientific registers based on written scientific texts should drive instructional decisions about what language to prioritize in a secondary science classroom. One of the chief weaknesses of this perspective is that it distorts the character of scientific discourse, which encompasses all the ways scientists use language to accomplish their work and is realized through registers that range from the informal and conversational to the highly technical and abstract. Transcripts of scientists working through their ideas exhibit the characteristics of other forms of face-to-face conversations; in their laboratories, scientists do not communicate in the language of journal articles but in elliptical utterances, gestures, and vague references and deictics ("this, "that") that lean heavily on the surrounding physical context (see, for example, Harris et al., in press; Kozma et al., 2000). This does not, however, make this language any less scientific. A second major flaw with foregrounding formal scientific registers is that such a position marginalizes other language varieties and can contribute to the damaging and false perception that the languages and language practices of multilingual

learners and racialized students are inadequate and inappropriate for conducting academic work. In fact, researchers have demonstrated how, in classrooms committed to recognizing students' sense-making and linguistic resources, students are able to construct and communicate precise scientific understandings using their own languages (Warren et al., 2001).

In this study, I adopt the position that in deciding what counts as the language of science, teachers must focus on the intellectual work being accomplished rather than the presence or absence of specific linguistic forms. If students are using language and other semiotic resources to engage in scientific discourse and sense-making practices, then they are using the language of science.

Supporting the Literacies and Languages of Science. The preceding discussion does not mean there is no space for introducing students to new ways of using language, including linguistic forms used in formal scientific registers. Indeed, I would argue that secondary science teachers should be expanding students' communicative repertoires, adding to the resources students can draw on to interpret, co-construct, communicate, and critique scientific ideas. However, this expansion is best accomplished not through direct teaching of specific linguistic features or scientific genres. Instead, following contemporary sociocultural accounts of language development that center opportunities for social interaction, I understand effective literacy and language support to consist of thoughtfully designing lessons that engage students in rich opportunities for collaborative, interpretive, and productive language use as they engage in disciplinary practices (Lee et al., 2019; Walqui & Bunch, 2019). When teachers do focus on form, it should be in the service of these broader goals. Moreover, teachers must do so in ways that truly amplify students' linguistic

resources, rather than (intentionally or not) replacing students' languages and language practices or promoting one-way assimilation into the language practice of white, monolingual, middle-class speakers.

Drawing on the work of Hammond and Gibbons (2005), I conceptualize language support as happening at both the macro level, in the form of planned scaffolding, and the micro level, in the form of interactional scaffolding. Planned scaffolding refers to the ways teachers intentionally organize instruction to help students engage with challenging disciplinary concepts, practices, and language. It includes the selection and sequencing of tasks and the choice of participant structures as well as the incorporation of strategies intended to help students interpret and produce language. A key form of language support is creating a meaningful context for language use, for example, by anchoring lessons in puzzling phenomena (Windschitl et al., 2018) or local phenomena and problems (Lee et al., 2019) or engaging students in investigations and engineering design projects. Planned scaffolding also includes strategies for supporting students to interpret oral language, such as ensuring that lessons contain "message abundancy," with information communicated through multiple channels (e.g., speech, gestures, visuals, and demonstrations, Gibbons, 2015). Similarly, planned scaffolding includes strategies for increasing the accessibility of complex written text, including activating students' prior knowledge, modeling active reading strategies, and providing opportunities students to collaboratively grapple with meaning as they read and discuss in small groups (Bunch et al., 2014). Finally, planned scaffolding includes strategies for helping students to produce language, including providing opportunities for rehearsal and revision and modeling target language (Walqui, 2006). This is

of course only a partial account of the types of planned supports available to teachers for supporting language.

In contrast to planned scaffolding, interactional scaffolding is contingent, determined by the ideas students share as classroom activities unfold (Hammond & Gibbons, 2005). In science education in particular, researchers have proposed a specific set of teacher talk moves that can serve as interactional scaffolds to support academically productive talk. Through these talk moves, teachers elicit student thinking so that it can serve as a public intellectual resource for other students, prompt students to clarify and deepen their reasoning. and re-voice student contributions in order to emphasize the salience of particular ideas or recast ideas so that they are easier to understand (MacDonald et al., 2014; Michaels & O'Connor, 2012; Windschitl et al., 2018).

Importantly, preservice teachers need to know how to implement language support in ways that do not compromise the cognitive demand of sense-making tasks. They must also be able to plan scaffolding that is responsive to students' current learning needs rather than simply provide routine support (Athanases & de Oliveira, 2014).

Language Ideologies

I have already indirectly touched on the influence of language ideologies in decisions about how broadly or narrowly to define the languages of science. In this section I more explicitly explore the ways in which language ideologies constitute sets of beliefs and ideas not just about languages but about language users. Unpacking language ideologies can help clarify the often-unexamined beliefs teachers hold about students' language use and their corresponding appraisals of students' intelligence and abilities. The links between evaluations of students' language use and judgements about students' abilities are critical to

examine in U.S. K-12 classrooms, where deficit orientations to racialized students' languages and language practices have historically displaced responsibility for academic failure from the systemic racism of educational institutions to marginalized students themselves (Valencia, 2010).

As introduced previously, language ideologies are "morally and politically loaded representations of the nature, structure, and use of languages in a social world" (Woolard, 2021, p. 1). Woolard emphasized that language ideologies are not inherently negative, but they are fundamentally *partial*, both in the sense of being incomplete and in the sense of serving a particular set of interests. Moreover, language ideologies are never just about language, but instead "forge links between language and other social phenomena," including "conceptions of personhood, proper human comportment, intelligence, aesthetics, and morality" (Woolard, p. 1). Woolard explained two conceptual tools the field of language ideologies has developed to understand the relationship between language forms and identity. The first is the concept of social indexicality, the associations that individuals naturally make between specific language forms and particular kinds of speakers. Language forms can index, or point to, not just macro social categories of race, ethnicity, social class, gender, and sexual orientation but also more specific social identities, such as "youth subculture orientation, occupational expertise, parenthood" and more. The second tool is the concept of enregisterment, the process by which constellations of linguistic features come to be seen as "typical styles or registers" and these styles or registers are then linked "as wholes with types of speakers" (Woolard, 2021, p. 9). Of particular interest in this study is how some students—those teachers do not recognize as using the right language or language practices—are enregistered as less capable students.

I now turn to two specific sets of language ideologies are likely to distort teachers' perceptions of multilingual learners and their languages and language practices: monolingual or monoglossic language ideologies and academic language ideologies.

Monoglossic and Heteroglossic Framings of Bi/Multilingualism. Monoglossic language ideologies include those beliefs and practices that presume that monolingualism is the norm and understand bi/multilingualism from a monolingual perspective. These ideologies misconstrue bilingualism as balanced fluency in two autonomous national languages, resulting in an understanding of bilingualism as a kind of "double monolingualism" (Flores & Schissel, 2014, p. 457). Consequently, teachers holding monoglossic language ideologies measure bi/multilingual speakers' linguistic competence against that of an idealized native monolingual speaker. Even in educational settings that reject monolingualism, such as dual language immersion schools, bi/multilingual students are viewed from a deficit perspective when their language practices do not conform to these ideals. In educational settings which do not reject monolingualism but in fact reinforce it—that is, in the majority of U.S. classrooms—monoglossic language ideologies mean that "learning is often equated with learning in English; primary language and literacy skills are rarely acknowledged and even more rarely used to facilitate learning; and teachers' monolingualism is not generally problematized, only students' bilingualism" (Palmer & Martínez, 2013, p. 273).

Flores and Schissel (2014) argue that in order to eradicate deficit views of bi/multilingual students, schools and teachers must adopt heteroglossic language ideologies, which presume dynamic bi/multilingualism is the norm. From a heteroglossic perspective, bi/multilingual speakers control linguistic forms that can be assigned to distinct national

languages but that are in fact integrated into one communicative repertoire, and translanguaging—fluidly moving across named languages and language varieties— is natural and skillful bilingual behavior. Without a shift to heteroglossic language ideologies, though, teachers are likely to continue to view bi/multilingual learners' translanguaging as a compensatory strategy and to underestimate their linguistic competence.

Academic Language Ideologies. The discourse around the construct of "academic language" has generated a formidable set of language ideologies that have become firmly entrenched in policies and practices aimed at improving academic outcomes for multilingual learners. As Valdés (2017) noted, the term academic language is used "casually, automatically, and uncritically by educators, researchers, and policymakers and in most, if not all, current writings in which language and schooling are discussed" (p. 335). Researchers have described academic language as a distinct register characterized by a detached and authoritative stance, high information density, tight organization, complex syntax, and formal, precise, and abstract vocabulary, among other linguistic features; these features are contrasted with their counterparts in "social" language (also referred to as "everyday," "colloquial," or "conversational" language) in order to highlight the difficulty of academic language (Snow & Uccelli, 2009). Researchers have also argued that the linguistic features of academic language are uniquely suited for realizing the language functions demanded by school and therefore necessary to teach explicitly (Schleppegrell, 2004). However, the discourse around academic language goes far beyond linguistic descriptions to encompass the "establishment of a new and enhanced symbolic border between two different categories of students: users of academic language and users of non-academic language" (Valdés, 2017, p. 339). Academic language is treated as an object, something some students

have and others do not, and low-achieving students' purported lack of academic language is used both to classify them as a certain kind of student and to explain their academic failure.

While the construct of academic language has been criticized on a number of grounds—Bunch and Martin (2018) are among many researchers who argue that it is a poorly defined concept that deflects teachers' attention away from students' ideas and to the surface features of their language—the most forceful critiques of academic language come from scholars who trace the devastating consequences of drawing borders around "academic" and "non-academic" language for racialized students. Flores (2020) explained how the academic/non-academic dichotomy is a product of the white listening (or reading) subject who cannot hear the language practices of racialized students as academic:

> A raciolinguistic perspective shifts the focus from the linguistic practices of the speaker/writer toward the perceiving practices of the listener/reader. From this perspective, whether one is positioned as successfully engaged in academic language is primarily determined by the white listening/reading subject whose perceptions have been shaped by histories of colonialism that continue to frame racialized speakers as coming from communities with linguistic deficiencies that need to be policed and corrected. (p. 24)

García and Solorza (2020) argued that these students are fully capable of using language for complex reasoning and communication, but because narrow definitions of academic language exclude these students' language practices, racialized students are enregistered as "non-academic" and condemned to colonizing efforts at language remediation.

It is worth noting that many researchers who promote the idea of academic language claim to do so out of a concern for improving academic outcomes for multilingual learners.

When Cummins (2008) first proposed the distinction between BICS (basic interpersonal communication skills) and CALP (cognitive academic language proficiency)—the foundation of much subsequent scholarship on academic language—he did so in part to address the misattribution of language or communication disabilities to multilingual learners, arguing that multilingual learners who quickly achieved conversational fluency in English but struggled academically were still in the process of learning English and in need of language support, not special education services. Nonetheless, his ideas "were taken up by educators in ways that did precisely the opposite – furthering inequity by legitimating the social order" (Thompson, 2021, p. 502). In short, the good intentions of academic language proponents do not alleviate the negative consequences of these ideologies.

To summarize, language ideologies—including but not limited to the monoglossic and academic language ideologies just discussed—animate teachers' understandings of their students' needs and abilities, often in ways that run counter to their more consciously held commitments to helping all of their students succeed. Palmer and Martínez (2013) contend that "the more pressing challenges in educating" multilingual learners "lie not in the learners themselves but in the language ideologies and normative discourses that permeate classrooms, schools, and the surrounding society" (p. 273). Critical reflection, which I define in the next section, is one way for teachers to exercise agency and begin to question these language ideologies and normative discourses.

Reflection and Critical Reflection

In this study, I distinguish between reflection and critical reflection. I use the term "reflection" to roughly encompass two types of reflection described by Valli (1997). The first type is reflection-on-action (Schön,1983), which suggests teachers should be guided by their

own unique "craft knowledge and personal experience" when appraising their experiences (Valli, 1997, p. 77). The second type is deliberative reflection, an approach which invites teachers to consider their experiences in light of a "variety of sources: research, experience, the advice of other teachers, personal beliefs and values, and so forth" (Valli, 1997, p. 77). I use the term "reflection" to describe teachers' purposeful examination of their classroom experiences either in light of their own contextualized knowledge or of a broader range of sources. What this type of reflection does not entail is examining one's teaching practice in relation to the broader sociopolitical context or social justice goals.

In contrast, I use the term "critical reflection" to denote the kind of reflection that *is* explicitly concerned with these issues. Critical reflection goes beyond considering one's own teaching practice and entails "analyzing, questioning, and critiquing established assumptions of oneself, schools, and the society about teaching and learning, and the social and political implications of schooling" (Liu, 2015, p. 144). Both types of reflection are essential for teachers' development, but it is *critical* reflection that is more likely to lead teachers to notice and question the role of language ideologies in their professional work. If teachers are committed to examining how schooling contributes to the disruption or reproduction of power hierarchies, including linguistic hierarchies, then they can continuously reflect on the language ideologies implicit not just in their own teaching practices but also in educational standards, institutional policies, professional development materials, curricula, and the advice of teacher influencers on social media. In short, critical reflection can be a tool for life-long professional learning of more linguistically responsive ways to support multilingual learners and for the unlearning of harmful language ideologies.

Summary

To summarize, in this chapter, I have elaborated on my conceptual framework, describing why it is imperative to unpack the role of language ideologies in preservice secondary science teachers' understanding of how to support the literacies and languages of science and to document evidence of their capacity for critical reflection. In the next chapter I present the methods I used to conduct my research.

III. Methods

In this chapter I first discuss my own positionality as a researcher before describing the context in which I conducted my study, my participants, and my approaches to data collection and analysis.

Researcher Positionality

I am not a disinterested researcher but have a strong personal investment in this topic, one rooted both in my experiences as a child and as a teacher. The daughter of American parents living in a small Italian city, I spent my early childhood speaking English with my parents and Italian with everyone else: with my peers and the nuns at my Catholic preschool; with my neighbors, playmates, and parents' friends; and with shopkeepers and waiters and others around town. I was confident in my linguistic authority and regularly corrected my father's Italian pronunciation even as my parents mailed my grandparents audio cassettes in which I could be heard telling stories and singing in an Italian-inflected English. But once I moved to the U.S. to begin kindergarten, I began to lose my connection to Italian, and entire summers spent in Italy slowed but did not stop the erosion of my language skills. And then one summer afternoon in Italy when I was ten or eleven, I abruptly lost my sense of ease with the language. In my memory, I am out in the bright sun with two children I had just met, playing and talking. At some point, they corrected my Italian, marking me as a linguistic outsider. For many years afterwards, any time I tried to speak Italian, I felt self-conscious and embarrassed. Even though it was only loosely connected to my cultural heritage—I would need to go back to my maternal grandfather's generation for a direct link— Italian was an intimate part of my childhood, and I felt the loss of the language as a real loss.

To be clear, I am not suggesting I have experienced anything close to the linguistic discrimination faced by multilingual learners. My school (and life) experiences are quite distinct from those of the vast majority of multilingual learners in U.S. classrooms, who are overwhelmingly racialized students whose home languages and bilingual language practices are seen—at best—as one-way bridges to academic English and at worst as outright obstacles to academic success. Few multilingual learners enjoy the privileges I did as a white, middle-class speaker of what is typically referred to as Standard American English. But given my own experiences of becoming alienated from a language that once felt familiar, I can understand why, beyond utilitarian or economic reasons, it is so important to sustain students' multilingualism and their connection to their identities.

In addition to my personal experiences, as teacher I have always worked with multilingual students, including so-called generation 1.5 students in "remedial" mainstream college composition courses, international students in university writing and reading courses, newcomer students in high school English Language Development classes, and bilingual elementary school students in literacy program. Across these contexts, I have witnessed first-hand how multilingual learners are marginalized both by institutional policies and teachers' harmful language ideologies. At the same time, I recognize that when I first taught courses on language development to prospective elementary school teachers, I often did so from the same structural perspective I critique in this study, uncritically introducing the concept of academic language even as I emphasized the importance of drawing on students' funds of knowledge. And I taught this way at the exact same time I was involved in a program with the explicit aim of promoting sociolinguistic justice, "self-determination for linguistically subordinated individuals and groups in sociopolitical struggles over language" (Bucholtz et

al., p. 145)! Thus, I appreciate how difficult it is to distinguish all the ways in which harmful language ideologies can seep into one's teaching and to reflect critically on one's practice.

Context

Below I describe the local institutional and broader policy contexts that shaped participants' experiences as preservice teachers.

Teacher Education Program

Participants were enrolled in a 13-month, post-baccalaureate teacher education program located at Coastal University, a research university in California. The secondary science and math track of this program included an explicit emphasis on preparing teachers to effectively teach multilingual learners and used fieldwork and coursework to try to accomplish this goal. In terms of fieldwork, preservice teachers completed three primary placements in secondary science classrooms, two of which could be at the same site.[2] Over the course of the year, preservice teachers gradually assumed more planning, teaching, and assessment responsibilities in their placements, and in the Spring semester they acted as the primary instructor for one course, known as their takeover placement. In addition to their takeover placement, preservice teachers also had what was called a literacy placement—that is, a placement in a remedial math, English, or similar course that typically enrolled high numbers of students with institutional labels designating them as English Learners and/or as students with learning disabilities. Preservice teachers' fieldwork experiences were primarily guided by cooperating teachers in each placement, a school site supervisor, and a university supervisor.

[2] During the first year of the study, preservice teachers also had the option to experience a one-month international placement, which two participants, Noah and Gavin, did.

In terms of coursework, preservice teachers completed three types of courses that included substantial attention to multilingual learners, including courses on academic language, content-area literacy, and science methods courses. Beyond the common set of language, literacy, and science methods courses, preservice teachers also had the option to take a bilingual methods course. Courses were taught by faculty from the teacher education program and the graduate program housed in the same school of education.

The science methods courses were grounded in a research-based framework of effective instruction for multilingual learners which initially consisted of four principles: leveraging students' cultural, linguistic, experiential, and intellectual funds of knowledge; engaging multilingual learners in the same cognitively demanding expected of all students; creating rich opportunity for language production; and providing disciplinary language and literacy support (see Meier et al., 2020, for more detailed descriptions of these principles). By the third year of this study, a fifth principle had been added to the framework: creating a safe classroom community, which enjoined teachers to intentionally cultivate a learning environment that nurtured equitable participation for all students. This framework was introduced early in the year and strongly emphasized in the capstone science methods course offered in the Spring quarter.

Broader Policy Context

In addition to the specific institutional context shaping participants' preparation, state policies also foregrounded the importance of language in science instruction and the needs of multilingual learners. One potentially powerful influence on participants was the edTPA, a performance assessment still used for initial teacher credentialing in California. As part of their edTPA portfolios, preservice teachers submitted written reflections, instructional

materials, video clips, and analysis of student work related to a three- to five-day lesson cycle. One section of the edTPA asked preservice teachers to identify language demands and supports of their lesson (defined in the edTPA as language functions and vocabulary, syntax, and discourse), and one of the fifteen rubrics used to assess preservice teachers' performance focused exclusively on this competency. Attention to language and to multilingual learners was also woven into other parts of the edTPA; for example, in the assessment section, preservice teachers were asked to analyze work samples from one of their multilingual learners. Because of the high-stakes nature of this exam, preservice teachers invested substantial time and effort to meet the expectations of effective language support for multilingual learners as defined by the edTPA.

Participants

Data were initially collected from three successive cohorts of preservice secondary science candidates enrolled in the teacher education program at Coastal University during the 2015-2016, 2016-2017, and 2017-2018 academic years. Table 3.1 summarizes demographic data for these participants. All participants completed the sequence of courses and fieldwork placements described above in a suburban school district. On average, approximately ten percent of students enrolled in the two junior high and three high schools where participants completed their fieldwork were classified as English learners (California Department of Education, n.d.); however, significant differences did exist between individual schools and classrooms. Table 3.2 summarizes information about each participant's takeover placement

Table 3.1
Participant Demographic Data

Name	Race/ Ethnicity	Gender	Home Language(s)	Proficiency in Additional Language(s)
Camille	White	F	English	
Charlotte	White	F	English	
Chelsea	White	F	English	
Claire	Multiracial	F	English	
Daniella	Latinx	F	English, Spanish	
Derek	Asian-American	M	English	
Elizabeth	White	F	English	
Eric	White	M	English	
Ethan	White	M	English	
Frederica	White	F	German	English, Spanish
Gavin	Multiracial	M	English	
Ingrid	White	F	English	
Jonathan	White	M	English	
Kelly	White	F	English	
Lucas	White	M	English	Spanish
Mary	Other	F	Armenian, Arabic	English
Mason	Multiracial	M	English, German	
Meghan	White	F	English	
Melissa	Asian-American	F	English	
Noah	White	M	English	
Pete	White	M	English	
Savanah	White	F	English	
Sofia	White	F	English	
Thatcher	White	M	English	
Timothy	Asian-American	M	English, Chinese	
Zeke	White	M	English	

Note: Race/ethnicity, gender, and home language data were self-reported.

.

Table 3.2
Participant Placement Information, Teacher Education Program

Name	Takeover Placement School	Takeover Placement Course[a]	Multilingual Learners in Takeover Placement[b]	
			English Learners	Reclassified Students
Camille	Foothill High	Engineering Physics	○	●
Charlotte	Mesa Junior High	CP Physical Science	●	◆
Chelsea	Live Oak High	CP Biology	◉	◆
Claire	Live Oak High	CP Biology	◉	◆
Daniella	Live Oak High	CP Chemistry	○	●
Derek	Canyon High	CP Chemistry	◉	◆
Elizabeth	Canyon High	CP Physics	○	Unknown
Eric	Mesa Junior High	CP Life Science	●	◆
Ethan	Live Oak High	Conceptual Physics	Unknown	Unknown
Frederica	Live Oak High	CP Biology	◉	◆
Gavin	Foothill High	CP Biology	◉	◆
Ingrid	Live Oak High	CP Biology	◉	◆
Jonathan	Canyon High	NGSS Physics	◉	◆
Kelly	Live Oak High	CP Biology	●	◆
Lucas	Foothill High	Engineering Physics	○	◉
Mary	Foothill High	Honors/CP Chemistry	○	◆
Mason	Foothill High	CP Biology	◉	●
Meghan	Canyon High	AP Environmental Science	○	◉
Melissa	Arroyo Junior High	CP Life Science	◉	●
Noah	Foothill High	Honors Chemistry	○	●
Pete	Foothill High	Engineering Physics	○	◉
Savanah	Canyon High	Honors Chemistry	○	○
Sofia	Live Oak High	CP Biology	●	Unknown
Thatcher	Canyon High	CP Physics	◉	●
Timothy	Canyon High	CP Chemistry	Unknown	Unknown
Zeke	Canyon High	CP Physics	○	●

[a.] CP refers to College Placement courses. NGSS Physics was a de-tracked course offered to all students. The Engineering Physics course was part of an admissions-based STEAM academy. [b.] Information about multilingual learners was taken from participants' edTPA portfolios and cross-checked against their interview responses. While most participants

used these two standard labels to describe their students, others described students using their own categories (e.g., “fluent in social English”). In some cases, it was not possible to determine the number of English learners and/or reclassified students. ○ indicates no MLL students. ⭘ indicates 1- 4 MLL students. ● indicates 5-10 MLL students. ◆ indicates more than 10 MLL students.

Data Collection

Participants included in this dissertation were part of a larger National Science Foundation-funded research study which collected survey, interview, edTPA performance assessments, and, for some participants, classroom observation data. A team of graduate students were involved in collecting this data; where relevant, I have indicated where other researchers participated in collecting the interview data used in the present study.

To answer my research questions, I used interview data collected during the Spring quarter of participants’ teacher education program. These semi-structured interviews lasted approximately one hour and included questions designed to elicit participants’ understanding of effective science instruction for both students in general and multilingual learners specifically; the role of oral and written discourse in science learning; and the eight NGSS science and engineering practices. Participants were also asked to reflect on the three- to five-day lesson sequence they submitted as part of their edTPA (see Appendix A for the full interview protocol). I conducted approximately one-third of these 26 interviews and other members of the research teams conducted the remaining interviews.

Data Analysis

All interviews were professionally or automatically transcribed and double-checked by members of the research team. Rather than coding predetermined linguistic units (e.g., response to an entire question), I coded natural meaning units (Brinkmann & Kvale, 2015, p. 235). I used Nvivo 12 to qualitatively code using a mixture of a priori and emergent codes (Strauss & Corbin, 1994) across three coding cycles.

In the first coding cycle I focused on identifying participants' concrete descriptions of students and of instructional practices for supporting science and language integrated instruction. To this end, I coded participants' descriptions of students' language- and literacy-related challenges; their references to opportunities for collaborative, interpretive, and productive language use (California Department of Education, 2014); and their descriptions of language and literacy supports. After an initial round of coding, I examined the intersection of the last two categories of codes in order to identify which language supports were discussed in relation to each language use type; this is how the codes are organized in Table 3.4. At this stage I also coded each of these already-coded transcript segments as applying to students in general or to multilingual learners specifically in order to later determine if there were systematic differences in how participants discussed language opportunities and supports for these two categories of students or in how they characterized these two groups of students' language- and literacy-related needs. Finally, where relevant, I added codes to indicate when participants referred to their personal backgrounds, placement experiences, or teacher education program coursework in these transcript segments.

Table 3.4

Codes Used in First Coding Cycle

Codes & Subcodes	Definitions
Understanding of students	
Defining qualities	*Participant describes English learners as students…*
Learning English	… who speak a first, native, or home language other than English and are still learning English.
Literacy gaps	…whose literacy (reading and/or writing) are not sufficiently developed.
Academic language gaps	…whose academic language is not sufficiently developed.
Learning needs	*Participant describes students as needing support for…*
Learning new vocabulary	…learning new scientific terminology.
Literacy support	…reading or writing in general.
Support participating	… participating in discussions and other collaborative activities.
Support for scientific discourse	…using oral or written discourse in disciplinary-specific ways, e.g., arguing from evidence.
Language opportunities	*Participant describes they ways in which they have students…*
Collaborative	…engage in discussions and collaborative activities.
Interpretive	…have student opportunities to interpret oral, written, or multimodal texts.
Productive	… oral or written language or drawings to communicate, e.g., exit tickets, essays, lab reports, assessments, presentations.
Language supports	*Participant describes supporting language by…*
Creating a meaningful context	…creating a meaningful context, e.g., through investigations, engineering design projects, phenomena, real-world examples, or examples relevant to students' lives.
Facilitating collaboration	

Codes & Subcodes	Definitions
Questioning	…using teacher discourse moves or providing guiding questions in order to deepen student thinking.
Providing rehearsal time	…giving students low-stakes opportunities to formulate and rehearse ideas, e.g., using think-pair-shares.
Structuring group work	…using structured approaches to group work such as jigsaws and gallery walks; assigning group roles; or strategically grouping students.
Facilitating interpretation	
Providing message abundancy	…supplementing oral or written language with visuals to clarify meaning.
Modifying reading task	…supporting reading by focusing on how students interact with the text, e.g., by modelling reading strategies, chunking reading task, or embedding opportunities for discussion and peer collaboration in making sense of texts.
Modifying text	…supporting reading by focusing on the text itself, e.g., by simplifying language, choosing texts to match Lexile levels, or modifying layout and design elements.
Providing translations	…providing texts in other languages or encouraging students to use translation tools.
Facilitating production	
Providing models and modeling language	…providing CER (claim, evidence, reasoning) templates and other templates for formal written assignments such as lab reports; demonstrating how to construct graphs and other types of scientific inscriptions; or modelling.
Providing sentence frames	…providing sentence frames or starters.
Providing word banks	…providing word walls or banks.
Encouraging multimodal communication	…encouraging students to use drawings to communicate understanding instead of or in addition to writing.
Allowing home language	…allowing students to write in home language(s).
Focusing on vocabulary	…frontloading vocabulary; analyzing roots and affixes; highlighting cognates; or otherwise focusing on vocabulary for use across different language use opportunities.
Category of students	*Participants comments apply to…*

Codes & Subcodes	Definitions
Multilingual learners	…English learners or reclassified students.
Students in general	…all students.
References to experiences	*Participant refers to…*
Personal	…their prior educational and other personal experiences.
School-based	…their classroom teaching experiences, cooperating teachers, or professional learning communities.
TEP Courses	…TEP courses or cohort.

In the second coding cycle, I focused on determining to what extent participants discussed their beliefs and practices in ways that were general, specific, reflective or critically reflective; the last two categories I defined based on the work of Liu (2015) and Valli (1997). Using the codes presented in Table 3.5, I coded each transcript segment identified in the first round of coding.

Table 3.5

Codes Used in Second Coding Cycle

Codes	Definitions	Examples
	Participant provides…	
General	…brief example from their teaching experiences OR general discussion of more abstract ideas.	"I know NewsELA, they can just, do the slide around the Lexile scale and you've just differentiated a text."
Specific	… detailed example from their teaching experiences OR specific discussion of more abstract ideas.	"Well, I like to use NewsELA so you can adapt the reading. …So, you can kind of talk with them and say like, "Here's the hot max level, here's the next level down, here's the next level down." And they can pick the one that

Codes	Definitions	Examples
		they can access the easiest, which is really nice."
Reflective	…accounts of teaching experience that include analysis or reflection, e.g., reflecting on their own strengths, struggles, and growth as teachers, the (dis)advantages of certain supports, and/or the outcomes of specific lessons.	"NewsELA is a risky resource for trying to maintain the integrity of the text while lowering reading level. ...My solution is more to focus on how students interact with the texts. So really trying to get them to bring in their annotating strategies from English class…."
Critically reflective	…reflection goes beyond individual teaching practice to question concepts, practices, or institutional arrangements that perpetuate inequality	pushing back on the idea Lexile levels as a fair description of students' reading skills and seeking more asset-oriented ways of understanding students' literacy abilities [hypothetical example]

In the third and final coding cycle, I re-read each interview looking for places where participants discussed languages other than English, academic language and related concepts, and scientific literacies, identifying these excerpts using the codes in Table 3.6.

Table 3.6

Codes Used in Third Coding Cycle

Codes	Definitions	Examples
	The participants' response indicates...	
Multilingualism	…beliefs about the roles of languages other than English in a mainstream science classroom or the value of multilingualism; understanding of the nature multilingualism; and/or discussion of their own (lack of) multilingualism.	"I'm just thinking of Spanish—there's a lot of root words that, kind of, cross over that you can use and it's kind of fun to incorporate a little bit of their language, if you can, into the curriculum."

Codes	Definitions	Examples
Academic language & related concepts	…beliefs about what academic language is, about the role of academic language in students' success, or about the registers necessary or appropriate for school science learning and communication.	"It's definitely really important to my class because there's so many kids who I think struggle a lot with the academic language. Like they can say things in their own words, or they'll try and explain things, but they'll leave out all of the science vocabulary."
Science literacies	…beliefs about reading, writing, oral discourse, or multimodality in relation to the science and engineering practices and/or scientific sense-making more generally.	"How would I engage my students in reading or writing? Developing models and constructing explanations. So, investigating phenomenon. They figure out what the phenomenon is, say if it's something like the redshift, then they should be able to explain what it is. I think the goal of science is to explain things that we see in the universe, or the goal of physics rather, and that's a language task."

Once I finished these three coding cycles, I used several different approaches to transform my extensive coding into a more focused and coherent set of research findings. Again, I started with the most concrete of aspect of my data analysis, the findings related to participants' understanding of effective supports for the literacies and languages of science. I used an Nvivo query to examine the intersection of the language supports listed in Table 3.3 and type of student (i.e., multilingual learners or students in general); this way, I was able to compare whether certain types of support were discussed more frequently in relation to

multilingual learners than to students in general, or vice versa. In making quantitative comparisons, I focused on the number of participants who discussed a particular support rather than on the number of times a support was discussed. To make qualitative comparisons, I used an Excel spreadsheet so I could organize side-by-side comparisons of how each participant described using specific supports for multilingual learners and/or students in general.

To arrive at my findings about the quality of participants' reflectiveness, I took a more holistic approach. I did conduct a series of queries to explore possible patterns: I examined the intersection of the different "types" of comments (general, specific, reflective, and critically reflective) with each of the languages supports listed in Table 3.4, with the codes for understanding of students in Table 3.4, and with the codes for language ideologies summarized in Table 3.6. I used these queries to identify the codes associated with more reflective comments. However, I also focused on repeatedly reading all of the excerpts coded as "reflective" and "critically reflective" to discern the circumstances that tended to prompt (critical) reflectiveness and the strengths and limitations of participants' reflections.

Finally, to arrive at my findings related to participants' language ideologies, I repeatedly read the relevant excerpts in order to identify themes in participants' representations of and beliefs about multilingualism, academic language, and scientific literacies. While participants occasionally made explicit metapragmatic statements—that is, they occasionally commented on the pragmatic aspect of language use, such as what type of language they considered "scientific" and therefore appropriate for the classroom—more often than not I inferred their beliefs from their use of specific terms such as "first language" or "native speaker." Often, I drew on the literature reviewed in my conceptual framework to

discern how participants were using these concepts. For example, I examined the excerpts coded for "multilingualism" to identify the ways in which participants understood multilingualism from monoglossic or heteroglossic perspectives (Flores & Schissel, 2014). At the same time, I remained open to themes not discussed in this literature. In characterizing participants' language ideologies, I looked for both broad patterns that held for the majority of participants and for exceptions to these patterns. During this analysis, I also looked for alignment between participants' representations of and beliefs about multilingualism, academic language, and science literacies and their explanations for using specific strategies for supporting the literacies and languages of science.

In the next chapter I present findings related to these three sets of analyses, beginning with a description of participants' language ideologies, followed first by an examination of their understanding of effective support for the literacies and languages of science and then by an exploration of their (critical) reflectiveness. In presenting these findings, I indicate the ways in which participants' language ideologies are reflected in their understanding of literacy and language supports and the ways in which they (do not) reflect on understandings and practices associated with different language ideologies.

IV. Findings

In this chapter, I discuss preservice secondary science teachers' understandings of how to support the languages and literacies of science for multilingual learners. First, I examine participants' language ideologies related to bi/multilingualism, academic language, and scientific literacies. In the next section, I document the types of support participants described using to facilitate collaborative, interpretive, and productive language use, comparing the types of support they report providing multilingual learners with the types of support they report providing students in general. I also connect participants' choice of language supports to the language ideologies discussed in the first section. Following this, I describe the ways in which participants engaged in (critical) refection.

Participants' Language Ideologies

Participants' language ideologies can be clustered into three broad categories consisting of their representation of and beliefs about bi/multilingualism, academic language, and scientific literacies.

Bi/Multilingualism

Participants were not asked any questions that designed to elicit their beliefs about bi/multilingualism; nevertheless, all but two participants touched on this topic at least once in their interviews. While it would be unfair to characterize any one participant's beliefs about bi/multilingualism based on the data I collected, some shared tendencies were evident: Participants tended to value students' home languages but also to understand bi/multilingualism from a monoglossic perspective. Moreover, they were inclined to characterize students' home languages from a structural perspective and to overlook the ways

in which language is related to identity or the broader sociopolitical context. Below I describe in more detail the evidence for these claims.

The Value of Languages Other Than English. Most participants described the value of having multilingual learners in their classrooms, explaining how such students brought distinct experiences or perspectives that could serve as a resource for science learning and for building interpersonal connections across differences. In contrast, only one participant explicitly commented on the value of bi/multilingualism per se: Jonathan, who had been an engineer, explained that he had first-hand experience working in the global economy and maintained that knowing multiple languages was "preparing [students] to be a part of that global economy." He remarked that while learning English was "really challenging" for his multilingual learners, it was also "such a blessing" to be multilingual.

However, eight participants did discuss the ways in which speaking a language other than English could be a resource; overwhelmingly, these participants noted that students' knowledge of other languages (typically Spanish) was helpful for learning scientific vocabulary. For example, Camille explained:

> English language learners might know some of the academic vocabulary we learn in science class in their language…and that might be really interesting in class because you can kind of break down the root of the word and that I think would help lead to a deeper understanding of the vocabulary for all the students.

In this quote, Camille indicates that multilingual learners' knowledge of other languages can help all students learn new scientific terminology, a position expressed by many of these eight participants.

More generally, approximately one-third of participants described situations in which they would use students' home languages, for example, by pairing newcomer students with bilingual peers, providing home language translations, or allowing students to write in their home language, strategies I return to in the section on supporting the literacies and languages of science. While such practices are not explicit affirmations of the value of bi/multilingualism, they do indicate participants at a minimum saw a role for students' home languages in otherwise monolingual science classrooms.

The Value of Speaking Students' Languages. Participants communicated their views of bi/multilingualism in relation not just to students but also themselves. More specifically, ten participants portrayed their (lack of) fluency in students' home languages as facilitating or constraining their sense of preparation to teach multilingual learners. The three participants who identified as Spanish speakers indicated that this ability contributed to their sense of confidence or enthusiasm for working with Spanish-speaking multilingual learners. For example, Daniela shared that, "I think specifically in this district, I feel really confident…because I'm bilingual, so I speak Spanish, so I feel like I could support those students." However, participants seemed to regard their own bi/multilingualism as an asset only if they spoke the same language(s) as their students. Daniela continued, "I don't know how confident I would be in a different type of classroom with different backgrounds," explaining "I just think personally I would find it a little bit more challenging obviously if I had someone who spoke Mandarin and I have no way to make connections." Similarly, Mary, who spoke Armenian and understood Arabic, recognized that if "I went back home and taught in my home area that [her proficiency in these languages] would be completely useful" but was concerned because "Spanish is a really dominant language and I want to be

able to allow students to understand things in their language." She described feeling unsure about how she could incorporate students' home languages if she did not speak these languages:

> A lot of our conversations about English language learners [in the teacher education program] involve allowing them to use their home language in understanding, which I would love to implement, but then I just don't know how I would. Like, how does that work if I don't understand the home language?

Both Daniela and Mary valued their own bi/multilingualism when they shared a common language with their students, but they did not comment on the insights they might have as bi/multilinguals even in situations in which they did not speak students' home languages. Relatedly, Mason and Timothy, the two other multilingual participants who did not speak Spanish, did not mention their own language abilities, perhaps because they spoke less-common home languages.

Of the ten participants who commented on their own language abilities, five participants who identified as monolingual English speakers also referred to their inability to speak Spanish and characterized this inability as a disadvantage. Some participants simply indicated that they did not feel fully prepared to teach multilingual learners because they did not (fluently) speak Spanish. For example, Meghan said "I feel like I would feel a lot more prepared if I had stronger Spanish." However, other participants provided more detailed rationales for wanting to speak or learn students' home languages. For example, Melissa described feeling unable to "genuinely" validate her students' home languages without being able to speak these languages:

> I think what could really make me feel more prepared, would be learning Spanish, in this case, or learning the language that my students are coming in knowing. Because we talk so much about, you need to be validating their experiences and their home language, and contextualizing it in their culture and language, and I don't feel that I can do that genuinely without having a deeper grasp on the language. I think it sounds really nice. I think, right, I definitely value it, but I don't feel genuine about engaging their home languages when I can't speak it myself. And that feels bad.

In this quote, Melissa grappled with the deeper issue of how she can authentically ground her instruction in her multilingual learners' linguistic funds of knowledge when she does not share them. As a second example, Pete suggested that learning his students' home languages could signal to these students that he recognized and appreciated the challenges they are facing and so could be one basis for stronger relationships with his students:

> I think if I did have a high portion of English language learners in my classroom, I would do my best to learn at least the opening ideas of their language, just to get an idea, and just to even show I'm trying. Like, "I see you struggling with English. I'm struggling to learn your language," whatever it may be. I think that connection would mean a lot.

While some participants might have had primarily practical reasons for wanting to speak or learn their students' home languages, at least some participants considered other advantages to becoming bi/multilingual themselves.

Understanding Multilingualism from a Monoglossic Perspective. While participants expressed a positive orientation to bi/multilingualism, they often discussed it

from a monoglossic perspective, one which interprets the world through a monolingual lens. These ideologies are apparent in participants' discussion of the relationship between students' home languages and English. For example, of the twelve participants who defined English Learners[3] as students who were still in the process of learning English, ten differentiated between a student's *first language* and *second language* or otherwise assumed students spoke a single language other than English at home; these responses are presented in Table 4.1. Only two participants indicated the possibility of bilingualism: Melissa defined English Learners as students "whose *primary home language* [emphasis added] is not English" and Meghan defined them as students "who ha[ve] a *primary language* [emphasis added] other than English." Participants' use of the terms "first" and "second" languages also suggested they saw the development of bi/multilingualism as a linear process of acquiring discrete additional languages rather than as an expansion of a unified linguistic repertoire.

Participants' monoglossic perspectives were also evident in the ways they discussed using students' home languages to support the literacies and languages of science. Participants generally described using students' home languages in terms of translation: They spoke of translating texts into their students' home languages, allowing a student to write first in their home language and then use Google translate to produce an English version, and pairing a multilingual learner with a bilingual peer who could translate for them. That is, they

[3] This was the term for multilingual learners used in the interview protocol. Of course, a monoglossic framing is inherent in the term "English Learner" itself, which suggests the students speak a different language and are learning English as an additional language, rather than understanding them as bi/multilingual language users. It is worth bearing in mind how the language used in the interview protocol might have shaped participants' responses.

generally portrayed multilingual learners as *either* using a home language *or* English in the classroom rather than fluidly drawing on their full linguistic repertoires. Participants did not indicate that they encouraged multilingual learners—or bilingual students who did not "need" to use languages other than English—to engage in bilingual practices such as translanguaging. This is not surprising, given that "mainstream" classrooms in the U.S. could be more accurately described as monolingual classrooms (Hinton, 2016).

Table 4.1

Participant	Definition
Camille	"a student who English is not their first language"
Charlotte	"a student where they were born and the first language they heard wasn't English"
Chelsea	"anyone whose first language wasn't English"
Daniela	"anyone who English is not their first or dominant language"
Eric	"students where English is a second language"
Ingrid	"English is not their first language"
Jonathan	"anybody that has learned a different language first and is now working on their second language as English"
Kelly	"someone whose language or first language is not English"
Mason	"I just have a lot of students that struggle with the English language because a lot of time it's not something that was the first language they were exposed to"
Timothy	"someone who grew up speaking a language other than English"

Understanding Bi/Multilingualism from a Structural Perspective. When discussing students' home languages, most participants tended to adopt a structural

understanding of language. As described in the section on the value of other languages, participants were most likely to describe multilingual learners' linguistic resources in terms of their knowledge of linguistic forms (i.e.., shared Latin roots and cognates that could facilitate vocabulary acquisition in English). Additionally, two participants discussed how students' home languages could accelerate or complicate the process of English acquisition; both participants focused on the structural features of students' home languages. For example, Timothy explained that a multilingual learner whose home language was Spanish would have a different experience learning English than on whose home language was Chinese:

> I think there's a huge difference between someone who is an ELL who spoke Spanish growing up versus someone who is an ELL speaking Chinese….because I think the structure of a language can totally affect how they approach English, and if it's a language completely different from English, a language that they learned growing up is structurally different than English, they might have trouble translating it to like syntax. Or I think some students learning languages that are similar to English will have a better time.

Of course, languages do vary in terms of their structures, and the fact that science teachers are able to acknowledge both linguistic similarities and differences across languages should be acknowledged as a strength.

However, it is notable that few participants discussed students' home languages in relation to students' social and cultural identities or to the broader sociopolitical context. One of the few participants to do so was Lucas, who was white but grew up partly in Mexico and was fluent in Spanish. Describing how his Latinx students reacted when he tried to speak

Spanish with them, Lucas noted that some students did not want to speak to him in a language they might reserve only for social intimates or cultural insiders:

> Some of them think it's great and take a lot of pride in it. Some of them are like, "Why are you talking to me in that language? I only talk to that language with my parents or cuss my friends out in that language. And it's not something that I want to share with you." So, it's very tricky.

In this quote, Lucas recognizes that language is never just a neutral medium of communication but is bound up in issues of identity, and that bi/multilingual students might not be receptive to a teacher's attempts to use their home language(s), which they might perceive an act of cultural appropriation. While Lucas acknowledged the complex dynamics shaping students' willingness to speak their home language(s) in traditionally monolingual English settings with interlocutors they perceive as cultural outsiders, no other participants elaborated on issues of identity in the interviews used in this study. It is important to underscore that just because participants typically discussed language in structural terms does not mean they were not also aware of the social and sociopolitical dimensions of language use. However, their emphasis on language structure in discussing students' home languages is consonant with their emphasis on language structure when discussing academic language.

Academic Language

While participants were not asked directly to define or comment on the concept of academic language, approximately two-thirds of participants used the terms "academic language" or "academic English" in their interviews. Most participants used these terms to refer to a specific variety of English distinct from "social" English, yet they also frequently treated academic language as if it were synonymous with disciplinary vocabulary. Some

participants attached greater significance to the term, invoking the construct of academic language to explain students' academic challenges and/or to establish symbolic borders between types of students. I explore each of these patterns in greater detail below.

Describing Language. The majority of participants who used the term academic language did so as if it were an unproblematic concept that described a language variety with an objective existence. For example, Lucas indicated that to work effectively with multilingual learners, teachers should be familiar with the general characteristic of both English and academic English:

> So, I think being a good science teacher, secondary science teacher to ELLs, is being aware, not only of the uniqueness of language in terms of just the general English language, but then recognizing within that, okay, there's the register of academic English.

Similarly, Chelsea indicated that "modeling academic language" was the teacher's responsibility in a science classroom and Timothy suggested teachers needed to "give students the opportunity to have a voice in the classroom, but also using that voice with academic language."

In using the term "academic language," some participants also emphasized its distinctiveness from "social" or more easily accessible language. For example, Elizabeth explained that "I use a lot of academic language" in the notes she provided students, and she speculated that if she had more multilingual learners in her classroom she would provide students two-sided handouts, "where one side is academic and one side is more social language." Similarly, Charlotte described differentiating for her multilingual learners by "taking a lot of the academic language out and making it more simple." As a final example,

Mason remarked that, in a unit addressing how energy travels through an ecosystem, he had avoided emphasizing vocabulary and instead spent "a little bit more time on trying to get the conceptual points across in the lower academic language."

In describing language as "academic," many participants tended to blur distinctions between academic language, academic vocabulary, and academic English. For example, in the quote below, Zeke shifted between describing a kind of register, "academic English," and referring to vocabulary, "content specific words":

> I feel like basically all of my students are English language learners. Because, and I kind of am too….Everybody has to learn academic English in school, and not everybody is fluent in it, and similarly content specific words. We're teaching them parts of English that allow them to communicate ideas in a specific discipline, and that's true for all the students in my class.

Similarly, Derek explained that before he joined the teacher education program, he never realized "how heavy the academic language was in science" but that "through TEP and through teaching my own classroom, [he] realize[d] there's so many science words" unfamiliar to students and concluded, "You have to, somehow as a science teacher, integrate building up their academic language." In this example, Derek seemed to understand academic language to mean scientific vocabulary.

While most participants seemed to accept the existence and importance of academic language at least tacitly, at least one participant pushed back on this construct, not directly, but by asserting the value of students' ways of using language. When asked about multilingual learners' contributions to science classroom, Ethan remarked on how enthusiastic he was about "the idea that students can explain something using their own

terminology. They don't need the science vocab." He went on to describe a situation in which a multilingual learner, by using less technical terms, might be able to communicate science content more effectively than he could:

> I'm going to explain it by, "Oh, there's a greater force," but an English learner will say, "Pushes more" and then some people who aren't getting what I'm saying, they'll hear it in different words. And I think that it's a really powerful thing to be able to hear other people explain it in different ways and simpler language but still hitting at the same content.

Overall, though, participants described using less formal or "social" language as a scaffold, a one-way bridge to academic English, rather than as a valuable linguistic resource students could also draw on as they engaged in scientific sense-making. Participants' orientation towards academic language as the most appropriate register for communicating scientific understandings is also evident in the sections below.

Explaining Academic Challenges. A few participants used the concept of "academic language" to describe the language that all students naturally encounter and learn to use in school contexts. For example, in Zeke's quote in the previous section, he indicated students are unfamiliar with academic language not because they are academically unprepared but because they are new to a discipline. Similarly, Elizabeth maintained that all her students were "science language learners," explaining that, "when you're a freshman in high school, and you're just learning about electricity and magnetism, you're a language learner in that moment, because you don't know how to express your ideas yet."

However, approximately one-quarter of participants used the concept of academic language to explain students' struggles to perform as expected on language- and literacy-

related tasks or in school more generally. For example, Claire observed that her students use their "own words" rather than "science vocabulary" in contexts she would expect them to use academic language:

> I guess a lot of our classes have been focused on literacy, so it's definitely really important to my class because there's so many kids who I think struggle a lot with the academic language. Like they can say things in their own words, or they'll try and explain things, but they'll leave out all of the science vocabulary.

In this example, Claire not only equated academic language with science vocabulary, but also suggested that being able to use academic language/vocabulary is an important component of students' literacy skills. Similarly, Sofia explained, "I think that's [academic language] something I'm really struggling with my students right now" and described a specific student who when he did "any type of writing or anything like that…he is just so low. So low. Like academic vocabulary is just not there at all." In this example Sofia conflated academic language with academic vocabulary and characterized her student as someone who, because he did not use academic language/vocabulary, was "low."

Finally, although he was the only participant to do so explicitly, Noah suggested that students' challenges with academic language might be severe enough to account for their ability to succeed in science more generally. When asked why some students struggle in science classes, he responded:

> It could be that they're acquiring English and while they may have been born in this country, they could have come across so many roadblocks along the

way, that at this point when they're coming across much more academic language, their deficiencies are going to show that much more.

In some participants' accounts, "academic language" was not just a new register all students must learn to use but a kind of language that eluded struggling students.

Establishing Symbolic Boundaries. Five participants used the distinction between fluency in academic and non-academic language to establish symbolic boundaries between students whom they considered to be "English learners" and those they did not. For example, Pete defined an English learner as a student "struggling with an academic grasp on English, because conversational English is fine, but we're in an academic setting…it doesn't have to be somebody that English isn't their first language, it can just be someone that struggles with academic English." Similarly, Derek defined an English learner as "someone who struggles with academic language conversationally and in writing and reading," explaining that he knew students who "can speak English perfectly fine conversationally outside of the classroom" but struggle with writing or interpreting instructions and so "even if they are reclassified, I still feel that they need help building up that academically."

Overall, academic language ideologies were pervasive in my data. Most participants—approximately two-thirds of participants—used this term or a near synonym in their interviews and they did so uncritically, accepting academic language as a linguistic fact and embracing rigid distinctions between "academic" and "social" or "conversational" languages. And yet, participants did not uniformly emphasize the explicit teaching of academic language as a way to support the literacies and languages of science. Instead, the idea of academic language—and a related focus on the difficulty of certain linguistic structures—was most influential in shaping participants' approach to interpretive language

use, and specifically reading; it was less consequential for their understanding of how to support collaborative and communicative language use, a finding I return to later.

The Literacies of Science

Unlike the previous two sets of language ideologies, which have been described in the language ideologies scholarship reviewed in my conceptual framework, this final set of ideologies is more nebulous, concerning participants' understanding of scientific literacies, a topic not typically discussed as an example language ideology. However, teachers' beliefs about the role of discourse in disciplinary learning and their practices around providing these discourse opportunities fit Woolard's (2021) definition of a language ideology as a "morally and politically loaded representations of the nature, structure, and use of languages in a social world" (p. 1). In this case, the social world is the science classroom, which is characterized by specific epistemic, sense-making, and communicative practices.

Below I describe participants' beliefs about the role in science instruction and/or professional science of three types of language use: collaborative language use, the kind of interactive exchange typified by whole-class discussions or talk during small group activities; interpretive language use, the process of making meaning from oral, written, or multimodal texts, as happens when students listen to teacher's lecture or read an article; and communicative language use, the kind of (primarily) one-way expression exemplified by oral presentations and most writing assignments. I also describe any challenges participants encountered in facilitating collaborative, interpretive, or communicative language use if they cited these challenges as a reason for providing fewer opportunities for students to engage in a particular kind of language use. Finally, I comment briefly on participants' integration of

each type of language use with the NGSS science and engineering practices or scientific sense-making more generally.

Collaborative Language Use. At least once in their interviews, all participants discussed the benefits of providing opportunities for students to engage in collaborative language use with their peers. Most participants portrayed this kind of peer-to-peer interaction as central to effective science learning and contrasted it with passive forms of instruction such as learning from teacher lectures or textbooks. Participants frequently indicated that they wanted their classrooms to be animated by student talk. For example, when asked what she hoped an observer would notice students doing in her classroom, Chelsea responded that she wanted them to notice her students asking each other questions and reasoning through possible outcomes as they engaged in an investigation:

> I'd like an observer to see organized chaos of students thinking or exploring or wondering, "Oh, what happens if we change this? Oh, what happens if we do this?" Healthy amount of debate towards each other, and really good reasoning in why, "If we change this, this is going to happen, so it would be better."

When asked the same question, Thatcher described wanting the observer to notice how his students were constructing coherent scientific arguments as they worked together:

> I hope that the observer notices the students collaborating, speaking out loud, and engaging in discourse, and good scientific discourse…arguing from evidence… making their claim, citing their evidence and then making some sort of logical flow that justifies how that data supports their claim.

As a final example, Ethan indicated he wanted the observer to see students actively talking and arguing:

> They'd be talking to each other. They'd be arguing with each other, and I guess along with that they're collaborating with each other. There's really no one off on their own doing their own experiment. I do think that science has to be a community. It can't be done in a vacuum. It can't be done just by one person.

In this quote, Ethan explains that collaboration is not just important for student learning but a fundamental characteristic of science itself.

Overall, participants readily identified collaborative language use as fundamental to sense-making and discussed collaborative language use in relation to NGSS science and engineering practices such as *planning and carrying out investigations, developing and using models, arguing from evidence,* and *constructing explanations and designing solutions.* For example, Zeke described how students engaged in extensive collaborative language as they completed an engineering challenge:

> It was a lot of verbal communication between the students, because they were making all these design decisions in groups of like four or five, so there had to be like teamwork and compromise, and all that kind of communicating ideas, and making tradeoffs, and things like that.

In this example, Zeke describes the process of negotiating and communicating ideas as a critical component of the engineering practice of *designing solutions*.

Interpretive Language Use. A handful of participants were enthusiastic about reading, indicating they did or would like to engage their students in more reading to

strengthen connections between the literacies of school and professional science. For example, Ingrid described wanting to give students journal articles to read so that they could get a better sense of how science is typically communicated:

> Because I don't feel like in high school we want kids to be reading academic papers all the time, but I do think like once or twice, if we walk through it with them, it could be interesting for them to understand this is what scientists use to communicate ideas, you know?

Chelsea provided a similar rationale for giving her students research articles to read, emphasizing that students should know how to navigate such a key scientific genre:

> I'm big on finding actual research articles and dissecting those together. It's hard to find ones that are usually simple enough for junior high or even high school level to grasp, but I think that's really important…as a scientist that goal is to be published and to have these journal articles, and then you as a science student, you should know how to navigate those and read through those.

At the same time, almost half of participants remarked on the fact that they did not include enough reading opportunities and/or support reading as well as they could. For example, Frederica shared she "probably should do a better job at providing more reading and writing opportunities"; Melissa noted that "We don't do as much reading as we should probably in my class"; and Savannah remarked that "Reading wise, again, I could do a bit better." Like Frederica, Melissa, and Savannah—and unlike Ingrid and Chelsea—other participants who commented on the fact they *should* do more reading typically did not explicitly indicate they felt reading was an important part of science. Several participants

noted the lack of relevant, high-quality reading materials available to them, and almost half of participants commented on their students' reluctance to read in a science classroom or their students' literacy struggles. Some participants even characterized reading as counter-productive to their broader goals. For example, Thatcher explained that although he recognized the value of supporting students' literacy development, he would prefer to avoid giving multilingual learners texts if he could:

> I would consider not giving a lot of the reading assignments that I give my students now on the basis of, "Can I achieve my learning objectives and my science practices without the supplemental reading?" Even knowing that, to support ELs, you need to give them opportunities to read. Sometimes you have to make a priority judgment, is it more important for them to understand the concept, or is it more important for them to fight with the literacy?

In this example, Thatcher signaled that at times literacy goals conflicted with science learning goals and that he needed to make a choice between the two.

Although participants described avoiding textbooks, they typically reported using reading to reinforce students' content understandings or to make connections to interesting real-world examples. That is, even though they created or curated their own reading materials from online sources, they tended to describe using written texts in a more traditional way, as sources of information, rather than as an opportunity for students to practice critical reading skills. Of course, there were exceptions to this general trend, and some participants described using reading to engage students in the NGSS science practice of *obtaining, evaluating, and communicating information*. For example, as part of a lesson cycle on human population and land use, Meghan had students work in groups to analyze data related to population trends in

an assigned country, as well as to read articles about different types of population problems (e.g., overpopulation and underpopulation) and approaches to population management (e.g., China's one child policy). She explained how reading these articles gave her students the opportunity to practice evaluating sources and asking critical questions about how accurately scientific concepts were presented in articles written for the general public:

> I think what did end up coming out of that, that does relate to science literacy is evaluating what you read and how are these ideas presented. These aren't scientific articles. These are journalistic articles. How are these ideas presented with a bias, or what is the perspective of the author and how do we evaluate the perspective of the particular author, and how do we determine what the scientific accuracies or misrepresentations are?

In this example, Meghan asked her students not just to extract information from a written text but to evaluate how authors presented their ideas.

Communicative Language Use. Several participants specifically commented on the centrality of written communication in the dissemination of scientific knowledge and so in students' experience of science learning. For example, Ethan explained that he tried to communicate to his students the goal of science was not just to "make a big discovery" but to share it:

> I've tried to emphasize with my students that science is not for themselves. Again, trying to push this idea of the community. They'll collect a bunch of data and then that's not the end. You have to present your data to other people. There's no reason to make a big discovery and keep it for yourself. So, part of

> it is knowing how to communicate with other people and communicate your findings and convince them that your findings are true.

Although few participants described the importance of writing as explicitly as Ethan did, all participants did report regularly providing a range of opportunities to write, including warm-ups and exit tickets, lab reports, scientific arguments and explanations tied to investigations, and larger group projects. And while, as in the case of reading, some participants noted students' challenges with writing, many fewer participants invoked their own challenges supporting writing as a reason for not incorporating writing into their lessons.

Many participants integrated writing with the NGSS science and engineering practices of *developing and using models*, *constructing explanations*, and *arguing from evidence*. For example, Gavin described an assignment in which students had to use evidence from class activities and from a set of curated articles to answer the question, "What are the best arguments for the evidence of evolution as known by the scientific community?" He had his students revise their drafts multiple times in order to coordinate claims and evidence.

> Just kind of drilling in the student's head that your first time writing something, pretty much is not your last, and that you need, especially in the scientific community, to back up your arguments with evidence. You need to be able to communicate it well enough that people understand how those links play into your main point.

In this example, Gavin emphasized to his students aspects of academic writing generally—that writing is a process—and science writing specifically.

Overall, participants understood oral discourse and collaborative language use to be a central component of scientific sense-making. While they centered collaborative language

use in their discussions of effective science learning, they were more ambivalent about the utility of reading. Their beliefs about the value of writing were somewhere between their universal and explicit endorsement of collaborative language use and their more hesitant stance towards reading.

Participants' Strategies for Supporting the Literacies and Languages of Science

In this section I explore participants' understanding of effective language supports. I do this by examining the kinds of strategies they discuss having used or wanting to use to support collaborative, interpretive, and communicative language use. While in many classroom situations students are likely to engage in more than one of these language use types simultaneously, in the following sections I treat each individually in order to highlight differences in participants' overall approach. Table 4.2 summarizes the primary strategies participants reported using to support both students in general and multilingual learners specifically across the three language use types. In the following sections, I elaborate on the ways participants describe using these strategies and clarify any differences between the supports they reported using for students in general and for multilingual learners. I conclude each section with a brief consideration of how participants' approaches to each language use type relate to the language ideologies discussed earlier.

Table 4.2

Strategies Used to Support the Literacies and Languages of Science

	All Students	Multilingual Learners
Facilitating collaborative language use		
Questioning	●	
Providing rehearsal time	⭘	
Structuring group work	⭘	◘
Facilitating interpretive language use		
Providing multiple or multimodal entry points		■
Structuring reading task	⭘	
Modifying text	○	■
Providing home language translations		□
Facilitating communicative language use		
Providing models and modeling language	⭘	
Providing sentence frames	⭘	■
Providing word banks	○	◘
Encouraging multimodal communication	○	◘
Allowing writing in home language		□

Note: Circles represent supports PSTs discussed using for all students, including multilingual learners. Squares represent supports PSTs discussed using in specific ways for multilingual learners or that more PSTs discussed specifically in relation to multilingual learners. ● and ■ indicate approximately two-thirds or more of PSTs discussed a support. ⭘ and ◘ indicate between approximately one-third and two-thirds of PSTs discussed a support. ○ and □ indicate approximately one-third or fewer PSTs discussed a support.

Facilitating Collaborative Language Use

Preservice teachers discussed using three primary approaches to facilitating collaborative language use. First, the vast majority of participants indicated they provided guiding questions for small group activities and/or used discourse moves such as asking probing or pressing questions (Windschitl, 2018) in order to deepen students' thinking during whole-class discussions. For example, Camille indicated she facilitated discussions "asking, pressing, probing, those kinds of questions that can guide them in their sense-making or understanding of the concept." Participants also used questions to encouraging peer-to-peer talk. For example, Mason commented that when he approached small groups, he asked questions to "try to get students more involved in each other's points." Second, many participants described the importance of giving students time to formulate and rehearse their ideas in a low-stakes environment before sharing these ideas with a broader audience, for example, through think-pair-shares or write-pair-shares. Finally, many participants reported using structured approaches to group work, such as jigsaws, carousels, and gallery walks.

While most participants did not indicate they modified the first two approaches for multilingual learners, many participants did discuss additional steps they took when structuring group work. Many participants reported strategically grouping multilingual learners with "more capable" peers or with students they knew would be supportive. For example, Frederica explained "I group them a lot, and I know which kids are good to work with them [multilingual learners] and which kids are not so great. I have a handful of students who are very willing to be supportive with the ELLs." Other participants, like Ingrid, focused on grouping multilingual learners who were still in the earlier stages of learning English with bilingual peers who would not only be supportive but could also help

with translations. Ingrid explained, “That's something small, but I think it really helps to be around someone that you feel comfortable with and that speaks Spanish.” Although participants did not always explicitly indicate they paired *newcomer* students with more English-proficient bilingual peers, this could be inferred from their descriptions: Participants emphasized the importance of translation as a way to help students with less English experience participate rather than describing opportunities for bi/multilingual students to fluidly draw on their full linguistic repertoire regardless of “need” to do so. Importantly, all eleven participants who discussed strategic grouping as a support for multilingual learners explicitly or implicitly positioned multilinguals learners as students in need of support and never as the “more capable” peer.

Beyond strategically grouping students, several participants described how they modified or assigned group work roles with multilingual learners’ needs in mind. For example, Jonathan described pairing students together during a gallery walk activity so “they wouldn’t feel so isolated” and explained that as a result “some of the English language learners felt a little more comfortable.” Some participants also considered other students’ potential reactions and tried to manage social dynamics. For example, Sophia indicated that she would try to anticipate and preempt tension within the group, saying that she would be “mindful” when deciding whether or not to assign a multilingual learner to a specific role if it “might create tension between the group if they (the multilingual learner) aren’t understanding for some reason.”

Overall, when explaining how they supported collaborative language use, participants used strategies—questioning, rehearsal time, structured group work—intended to help students extend and clarify their thinking and to increase participation. When describing how

they specifically supported multilingual learners to engage in collaborative language use, they highlighted the affective and social dimensions of group work. They discussed drawing on students' home languages in the context of pairing multilingual learners with bilingual peers who could provide translations. Participants rarely mentioned academic language (or its synonyms) or other structural dimensions of language (e.g., syntax) in relation to supporting collaborative language use; instead, they emphasized collaborative language as a sense-making resource.

Facilitating Interpretive Language Use

To help multilingual learners interpret oral language, approximately two-thirds of participants indicated they would use visuals, demonstrations, and other forms of message abundancy to clarify the language they used when framing lessons, giving directions, going over notes, and lecturing. For example, Derek explained that teachers need to use "some sort of hands-on activity or phenomena" for multilingual learners when they explain content because "when [multilingual learners] directly observe it, it's so much easier to make the connection." Importantly, participants did not indicate they would use any type of support to help students in general (i.e., non-multilingual learners) interpret oral language.

In contrast, most participants described supporting all students to interpret written texts, with half of participants commenting explicitly on students' aversion to or struggles with reading. Zeke expressed an understanding shared by many of his peers when he said, "The native English speakers struggle with English literacy too, and sometimes more than the English language learners." To help students navigate these challenges, approximately two-thirds of participants reported structuring the reading task, that is, how they prepared students before reading or what they asked students to do with the text during or after reading.

Participants described front-loading key ideas, modelling reading strategies (e.g., annotating), chunking long readings into shorter sections spread out over time, and embedding opportunities for students to interact with the material they were reading. For example, Pete described how he preferred to have students read a small amount of text followed by a prompt of some kind:

> I really don't like giving paragraph chunks of reading. I'd much rather say, "Here's an idea, think about it. Here's a question, think about it. Here's some data, write what you see." I think that's a good way to go about it, is yes, they're reading the words, but they're also interacting with them.

He further explained that he used this approach because he felt interpreting scientific texts was a challenge for any reader, including those, like himself, who had significant experience in the field. Participants created opportunities for students to interact with texts not just individually but also in groups; in these cases, they described drawing on some of the same strategies (e.g., jigsaws and strategic grouping) they used to support collaborative language use.

In addition to structuring the reading *task*, all but two participants reported supporting interpretive language use by considering the written *text* in terms of linguistic accessibility and visual appeal. While some participants discussed these criteria for selecting or modifying texts in relation to students in general, many more did so in relation to multilingual learners specifically (see Table 4.2). In terms of assessing a text's linguistic accessibility, almost two-thirds of participants indicated they used or would use Lexile levels and/or software such as NewsELA, which automatically differentiates texts based on Lexile levels. For example, Elizabeth explained:

> I like to use NewsELA so you can adapt the reading…to their reading score. So, you can talk with them and say, "Here's the hot max level, here's the next level down, here's the next level down." And they can pick the one that they can access the easiest.

Elizabeth further explained that in selecting texts, she thought about "what are their [students'] interests, what is their Lexile score, what are they comfortable with."

Aside from NewsELA and Lexile scores, some participants indicated they relied on their own intuitions to select or modify texts. For example, Timothy said he prioritized texts that were "more digestible" and explained that "when I see a text and it's a bit wordy, even if it's like a good text, I would just cut it down myself just so I can get the core ideas across to the ELLs." Whether they used a software program or revised texts on their own, participants seemed to evaluate a text's linguistic complexity primarily in terms of vocabulary and syntax. For example, Zeke explained:

> The vocabulary, or how dense the sentences are sometimes can be a barrier to students. Or if you've got lots of phrases and clauses separated by commas, and big, long sentences, kids can't parse it, whether they're ELs, or not.

Consequently, when selecting readings for his students, Zeke looked for "easy sentence structure, easy to follow logic."

In addition to the linguistic component of written texts, participants attended to length, layout, and other visual elements. Many participants emphasized the importance of keeping readings brief, minimizing blocks of text, and including plenty of white space, citing students' potential affective responses when explaining why they selected texts that were approachable. For example, Melissa explained that:

> Most obviously to me would be if I know that a majority of my class is already struggling with language, I'm going to find something that is not three pages long of solid text so that when a kid is handed the reading they're already turned off to it.

Participants also described using images, color, bolding, and other visual elements to emphasize information in the text.

Finally, as well as modifying English-language texts, a handful of participants mentioned the possibility of providing multilingual learners texts in their home language or of translating assessments into students' home language. For example, Frederica explained that "for my Spanish speaking students…I will translate. Because I want them to be able to access the material. I'd rather have them do it like that then not at all." However, she was one of the only participants to report doing this regularly.

Many participants described text complexity in terms of Lexile levels or the difficultly of vocabulary and syntax, a perspective that aligns with academic language ideologies. Both reflect a structural understanding of language, one that foregrounds the static, decontextualized properties of language forms as the source of students' struggles.[4] Generic readability formulae of the sort employed by Lexile levels and NewsELA do not take into account how students' prior knowledge and experiences moderate the actual

---

[4] NewsELA and programs like it rely on readability formulae based on sentence length and word frequency, so that the easier versions of texts are achieved by substituting more common words for less common ones and by breaking up longer sentences into shorter ones. These formulae do not take into account discourse-level (e.g., text cohesion or coherence) or qualitative dimensions (e.g., conventionality of language or knowledge demands) of text complexity (Bunch et al., 2014). Whether this approach to simplifying texts actually maintains the integrity of the content or makes texts easier to read is debatable.

difficulty they will experience when reading texts of comparable linguistic complexity (Bunch et al., 2014). Nonetheless, many participants seemed to accept a student's Lexile level as an accurate measure of their reading ability, one that could be used to efficiently match texts to students across a range of reading contexts. In many ways their uncritical acceptance of the construct of "Lexile level" parallels their uncritical acceptance of academic language.

Facilitating Communicative Language Use

Approximately two-thirds of participants discussed using some sort of template or model to support communicative language use for all students. Many of these participants described using the claim evidence reasoning (CER) model to help students with the scientific practice of *arguing from evidence* in writing. For example, Daniella described a group project where students "had to make a claim, evidence, reasoning" about "something that is currently being affected or will be affected in the future by climate change" using "credible sources, like NOAA or NASA or the EPA." She explained the format was flexible enough to give students "room and space to be more creative and more detailed with their writing" but that it was straightforward enough that "it's also not too daunting of a task for someone who struggles with writing to be able to write a claim evidence reasoning." Daniella also commented on the disciplinary nature of this model:

> After they do it a couple times, they really get a hang of it, and they know what goes in each paragraph. And I think it's a good way for them to do some science writing, which is different, obviously, than the writing that they would do in an English or history class.

In addition to CER models, some participants described providing students with models for different types of scientific representations, such as graphs, pedigrees, and molecular models. For example, Mary noted that she provided students a "particle model convention sheet" that explained "this is what each symbol means, this is how you draw it" so that students could model endothermic and exothermic reactions.

Most participants reported providing multilingual learners additional support in the form of routine language supports such as sentence frames and, to a lesser extent, word banks/walls, particularly on assessments or for formal writing assignments (see Table 4.2). Savannah described sentence frames and word banks as "your cookie cutters" perhaps drawing a parallel between these kinds of rote language supports and "cookie cutter-" (or "cookbook-") style labs which require little scientific sense making. In fact, sentence frames and word banks were the two supports participants were most likely to mention but not explain in any detail. One of the few participants who did provide a specific example of how she used sentence frames was Kelly. She described giving her students sentence starters to use when writing a paragraph-length argument about the evidence for evolution, explaining that "I gave an example of sentence frames, 'Evolution is this…,' you know, 'Evolution has occurred because of this…,' 'A first evidence is this…,' 'I saw this…'". While participants indicated they initially used sentence frames and word walls to support multilingual learners, most participants indicated they saw these supports as beneficial for all students and so would offer them to everyone.

Participants also provided multilingual learners additional support by encouraging multimodal communication, or the combination of language and drawings.[5] Participants frequently discussed multimodal communication in the context of assessment, indicating that they were most interested in gauging students' content understanding and not their language skills. For example, Ethan explained that "as much as I want to support their language, I'm not really assessing their use of language." For this reason, he gave students the option to either write or draw answers on many assessments:

> If they can answer whatever question I asked using words, that's great. But if they want to draw a picture, if a diagram helps them and that gets the answer, then that's great, because that's what I want to know, is do they have the physics knowledge to answer the question.

However, while participants may have initially provided multimodal options to accommodate multilingual learners and other students with special needs (i.e., in accordance with the principles of Universal Design for Learning), many indicated they saw the broader value of this strategy and offered multimodal options to all of their students. At the same time, many of these same participants expressed some reservations about whether allowing students to communicate multimodally somehow compromised the rigor of their instruction. For example, Gavin, who was enthusiastic about allowing all of his students to use drawing on all of his assignments, nevertheless noted that "I think drawing is sometimes a cop-out."

---

[5] Participants primarily offered students this option as a way to compensate for perceived linguistic limitations, and so is most cases this strategy is distinct from the scientific practice of modeling.

Overall, many participants supported students in ways that aligned with their understanding of communication, particularly written communication, as an important dimension of scientific activity, and they used strategies, such as modeling, that integrated attention to discourse and scientific practices. At the same time, when providing addition support for multilingual learners, the vast majority of participants also defaulted to sentence frames and word walls. However, because they typically did not provide rationales for using sentence frames and word walls, it is difficult to say whether they did so to prompt students to use academic language or for other reasons.

Evidence of Participants' Capacity for (Critical) Reflection

In this section I describe evidence of participants' capacity for reflection on beliefs or practices associated with the three broad categories of language ideologies described throughout this chapter: participants' orientations to bi/multilingualism and/or their use of students' home languages, their understanding of academic language and/or use of supports broadly aligned with academic language ideologies, and their beliefs about scientific literacies and/or use of supports for engaging students in scientific discourse. Before I present my results, it is important to acknowledge that I am not making claims about any one participant's overall capacity for reflection, which would be unfair to infer based solely their responses in one interview. Instead, my intention is to try and discern patterns in the beliefs and practices that participants as a group most commonly reflected on.

Reflection

All but two participants made at least one reflective comment at some point in their interview, and a number of participants made several. They were most likely to reflect on

either their students' challenges engaging in scientific literacies or their own challenges facilitating their students' engagement in scientific literacies.

Bi/multilingualism. Few participants made reflective comments related to their understanding of bi/multilingualism and/or use of students' home languages. As described in the section on participants' understanding of multilingualism, several participants did reflect on the implications (not) speaking their students' home language. Melissa's comment that she did not "feel genuine" about using her students' home languages is one example of such a reflective comment. A second example—his one made in relation to using students' home languages—comes from Sophia, who reflected on her cooperating teachers' practice of giving Spanish-speaking multilingual learners assessments in Spanish. While she was initially impressed by this strategy, her own observations and a discussion she had in one of her teacher education courses prompted her to rethink the efficacy of teaching students in English but testing them in Spanish:

> Originally, I was like, "Wow. That's so great."…but then we were in class just now, two or three weeks ago, and it was like, "Okay, well, teaching them in English, and then having them try to reverberate that in Spanish is not helping anyone." So, that was something that was eye-opening for me, because I kind of was putting the pieces together. I'm like, "I'm not sure if that's helping them," because they're learning in one language, and kind of those expectations are being highered and highered, and then we get to the test, and it's like, "Okay, well, we're just going to give it to you in Spanish." They haven't been working with the material in Spanish.

In this example, Sophia explained how her thinking about using students' home languages for assessments changed as she observed what was happening in her takeover placement and reflected on these experiences with colleagues in her teacher education course.

Academic Language Ideologies. Few participants made reflective comments related to beliefs or practices roughly aligned with academic language ideologies. In fact, the only reflective comments in this category involved participants who reflected on their use of literacy supports that drew on structural models of text complexity described in the section on facilitating interpretation. Sophia described using NewsELA to differentiate texts so her students could choose what level of text to read, noting that she had been careful not to single out students she thought would benefit from reading easier texts:

> So, that's the biggest thing, I think, that I've been really mindful of, is making sure that I'm leveling in some way that isn't super aggressive and obvious like, "Okay, everyone gets this paper. Except for you, you can have this one."

Sophia did not reflect on the model of text complexity built into NewsELA but did purposefully consider how she used the differentiated texts produced by NewsELA.

A second example comes from Mason, who reflected on the utility of the website Rewordify.com, a website that claims to reduce text complexity by simplifying potentially confusing words and phrases. He both interviewed a multilingual learner to find out whether he found Rewordify.com helpful and he observed how this student reacted to being able to use a tool independently compared to being offered supports:

> He hates it when I'm breaking down things for him and giving him a sentence starter…He just wants to do it on his own, and so he won't ask for the help. So, he was saying it's cool that he has a tool that he can just use himself to

> figure things out. It helps him, and it's me extending help to him, but it's not as much. He feels like he's still doing the same work in some sense. He's able to get better at the reading instead of it being a crutch.

Like Sophia, Mason did not reflect on the model of text complexity assumed by Rewordify.com, but he did reflect on why this tool appealed to this student more than other types of support.

Scientific Literacies. Approximately three-quarters of participants reflected on students' challenges engaging in scientific discourse. For example, Kelly commented on the challenges her students had with the practice of *engaging in argument from evidence* in a unit on evolution. Although she expected her students to use different categories of evidence to construct a written argument, she noticed that students "just defined each category instead of us[ing] the category as an argumentative tool." She explained:

> For instance, they knew that DNA was evidence for evolution, but they didn't know how to talk about, how to argue about DNA, how the closer the DNA sequence, like humans and monkeys, the closer those sequences are, the more recently they had a common ancestor.

In analyzing her students' challenges with this assignment, Kelly focused on their ability to reason in scientifically valued ways, not on linguistic forms or even the overall readability of their prose.

A second example of this kind of reflective comment came from Noah, who considered the challenges his students experienced with the practice of *developing and using models*. He explained that while he expected his students to produce a scientific model of

what was happening at the molecular level during endothermic and exothermic chemical reactions, his students simply drew pictures:

> So, we created a convention of using dots and arrows to signify particles and particle movement…and so we try to get them to use those illustrations to show a before and an after of what the particles would be doing in either an endothermic or an exothermic reaction. And it seems like as instructors, we were fairly consistent in asking for that as a practice, but…they always wanted to revert back to just drawing a picture. When you would say, model heat or something like that, model something, they would want to draw a candle or a flame.

Like Kelly, Noah was not concerned with form per se (i.e., using the dot and arrow conventions) but with his students' fundamental misunderstanding of what modeling entails.

A number of participants reflected on the challenges they experienced as teachers trying to engage their students in scientific discourse. Approximately one-third of participants reflected on the ways they asked questions or orchestrated discussions. For example, having observed that her students "shut down" when she only asked open-ended questions, Melissa consciously decided to vary her questioning strategies and to be more mindful of how she facilitated discussions:

> I just want to continue working on the questions I ask. I think there was a period of time where I thought, "Oh, the more open ended the question is the better. It gives students so much room and freedom to answer it however they want. And it's low risk because there's no right answer." But realizing that at some point you have to narrow the questions down and just because it's open

> ended, doesn't mean it's better, and that can't be the type of question you ask all the time, and that it's not wrong to ask questions that have answers, it's how you ask them and what you're asking them about. But I think for a while, I was like, "I want them to just think." And then realizing like, "Oh my gosh, this really actually makes kids kind of shut down sometimes," if it's not built up to and if it's not done the right way. And so, I am becoming more conscious of that and want to work on that in the coming years, weeks, months.

In this example Melissa not only reflected on her students' reactions to her initial questioning strategy but also signaled that this is a skill she intends to keep developing.

A handful of participants reflected on the struggles they experienced trying to engage their students in written discourse. For example, Timothy observed that he struggled to engage students in the practice of *constructing explanations* because even though he gave his students sentence frames, they often provided cursory responses in their written explanations. He then made a connection between his students' perfunctory explanations in their written assignment to shortcomings in his questioning strategies during discussions:

> Usually when they see those sentence frames, it's usually like, "Oh okay. I can just write one word and that will be it and then my explanation will be done." So, I don't know how to better scaffold it so that I get the responses I want. But I also think I just might need to give students more opportunities in my class to have these explanations, because I think a lot of times maybe the questions I'm asking in class are like one-word-answer questions, and then they just translate

> what happened in the class to their tests or their labs and just give me one-word answers.

In this example, Timothy indicated that he was still unsure how to elicit the kinds of scientific explanations he would like students to produce but that he had an idea about what he might need to change. In reflecting on their struggles to engage students in scientific discourse, many participants indicated that they still had unresolved questions or were actively searching for more effective approaches.

The Limitations of Reflection. While it is essential for teachers to engage in the kind of reflection described so far, this kind of reflection also has its limitations. Without critical reflection, teachers can make incremental improvements to their practice while also reproducing problematic ideologies. For example, Charlotte explained why she intentionally created heterogenous learning groups to ensure multilingual learners were not excluded by high-achieving but uncooperative peers. She reflected on the advantages of creating groups with strong students, middle-of-the road students, and English learners:

> I would typically group in fours, so I will take one of my stronger students, one of my ELs, and two of my, like in the middle of the road students, because I've found that if I pick a strong student with an EL…. they don't communicate at all. Either it's like, I don't know that kid, so I'm not even going to talk about it, I can do this by myself anyway. They have a little bit of animosity towards it, which drives me crazy. When I put them with two middle-of-the-road students, there's a nice little meshing of one of the students in the middle will maybe gravitate more towards the higher-level student, and

> then the other middle of the road student will gravitate towards the EL. It creates a nice little group.

Although Charlotte noticed the social dynamics of group work could exclude multilingual learners and adjusted her grouping strategies to better include them, she also implicitly positioned multilingual learners as being the "low" students in such groups.

Critical Reflection

So few participants made comments that approached critical reflection that it was not possible to organize these comments in relation to the three groups of language ideologies discussed in the previous section. Lucas' observation that his Latinx students did not always react positively to his use of Spanish, described in the section on language ideologies related to multilingualism, is one example of a reflective comment. After describing another incident where this attempts to speak Spanish were rebuffed—this time, it was welcome night for 9th graders entering the school's engineering program, and though he spent the evening speaking Spanish with students' families, the students themselves would only speak English with him—Lucas concluded that "practically speaking, honoring diversity in the classroom can be tricky if you're not of the same, you know, if you haven't been through the same experience as your students." While Lucas did not explicitly refer to his own race/ethnicity, he did indirectly reflect on his own positionality as a non-Latinx speaker of Spanish.

Based on the limited sample of critically reflective comments, it seems some participants also noticed institutional practices that marginalized multilingual learners. For example, Gavin observed:

> I have a couple students in my English 3 class [a remedial English class] who are incredibly bright, and just because they don't know English is the reason

> they're in there. That doesn't translate to how well you can do other things, but it does sometimes but up against the education system that we have in America. I think that's where you see these failings start to happen, and that because English is our language of instruction, someone who doesn't know it, no matter how well they know the content, no matter how well, whatever, we can't necessarily read what's in their heads and at some point they need to communicate to whoever is grading them. I think that's sometimes where you can see that disconnect.

In this example, Gavin stopped short of questioning the monoglossic language ideologies that produce the inequitable outcomes he described: He did not problematize teachers' monolingualism and assumed instead that multilingual learners need to accommodate to "whoever is grading them." However, he did recognize broader institutional inequities that impacted his students' learning opportunities. A second example comes from Thatcher, who expressed doubts about language support strategies being able to compensate for the larger institutional problems:

> EL instruction is missing that huge piece of buy-in, where we've developed our school system and our tracking where it seems like if you're an EL student, that means this science class is not really your place. We've kind of put you in conceptual physics, in this lower, just to kind of get rid of you, to push you aside. And that just wreaks havoc on buy-in, and none of those strategies matter. None of the—like, trying to get students to communicate in a pair share. They just won't do it, or they won't care. And I think it's internalized if they don't feel connected. That's where my doubt comes in, is that when ELs

> don't feel connected to the science or connected to the classrooms or their participation and there's just no buy-in, then not only do you—they stop, their learning suffers, but then they start to misbehave, and all other sorts of bad stuff happens.

In this example, Thatcher claimed that when multilingual learners feel marginalized, they disengage from learning and misbehave, a position that could be interpreted as evidence of deficit thinking. However, he recognized that multilingual learners are reacting to tracking practices that communicate a basic disregard for their meaningful inclusion. That is, he framed the disengagement he witnessed as an understandable response to institutional conditions.

In conclusion, participants made few critically reflective comments, and while a number of participants reflected on their students' and their own challenges with scientific literacies, they rarely reflected on beliefs or practices related to bi/multilingualism or academic/structural language ideologies. However, this conclusion should be interpreted cautiously, given that these results are based solely on interview data.

Summary

In this chapter I described participants' language ideologies; documented the types of support participants reported using to facilitate collaborative, interpretive, and productive language use; and presented evidence of participants' capacity for (critical) reflection. While I have suggested some connections across these three sets of findings, in the next chapter I more thoroughly synthesize and discuss these findings.

V. Discussion and Implications

In the preceding chapter I described participants' language ideologies and indicated some of the ways in which their strategies for supporting the literacies and language of science mapped onto their understandings of multilingualism, academic language, and scientific literacies. In this chapter I first synthesize the strengths and areas for growth in participants' understanding of how to support the literacies and languages of science in relation to the three dominant language ideologies. Following this review of my findings, I note the limitations of my study and then discuss my findings. Finally, I conclude this chapter with recommendations for practice, theory, future research, and policy.

Synthesis of Findings

Participants held positive orientations to multilingualism and recognized how students' home language(s) could be a resource for science and English language learning, primarily for multilingual learners themselves but in a limited way for other students as well. Participants also described a number of specific ways in which they used students' home languages, including pairing multilingual learners with bilingual peers, providing translations for assessments, allowing newcomer students to write in their home language, and highlighting Latin roots and cognates as a vocabulary learning strategy. Participants' willingness to use students' home languages in particular seems to have been reenforced through their teacher education program, as multiple participants commented on the fact that they knew they should be validating students' home languages and cultures, even when they were unsure how to do so skillfully. At one level, then, preservice teachers expressed asset-based understandings of their students' bi/multilingualism. At the same time, this understanding was embedded in monoglossic language ideologies that assume English

language acquisition should be the fundamental, and perhaps only, goal for multilingual learners. Consequently, participants described incorporating students' home languages primarily as a temporary and compensatory strategy for newcomer students or students who did not have sufficient English language proficiency to access the science curriculum in English.

Participants frequently referred to what they had learned about language in their teacher education coursework, and one positive outcome of participants' exposure to the construct of academic language and to structural views of language more generally is that they in fact developed linguistic knowledge: Many participants spoke accurately and specifically about the challenges of the vocabulary and syntax students might encounter in a science text. However, participants' typical uncritical acceptance of the construct of academic language led some participants to make simplistic distinctions between social and academic registers and to make blunt assessments of students as competent in social language but struggling with academic language. Beyond the specific construct of academic language, many participants also held structural views of language, most evident in their acceptance of reductive models of text complexity and their tendency to resort to simplifying texts for multilingual learners and other students, that led to global assessment of certain students as struggling with literacy. Such generalizations about students struggling with academic language or literacy—if they are reflective of teachers' actual perceptions of students and not just a shorthand employed in the course of an interview—can distort teachers' ability to perceive their multilingual learners' strengths and challenges in more dynamic and contextualized ways, in relation to specific tasks, and so to provide more responsive support.

Finally, in discussing how and why they incorporated opportunities for students to engage in collaborative, interpretive, and communicative language use, participants frequently indicated that they understood discourse—particularly oral discourse, but also writing—to be central to science learning and/or to the work of professional scientists. They described providing students with many opportunities to engage in both oral and written discourse and the science and engineering practices promoted by the NGSS. They also described using strategies to support collaborative language use (questioning, rehearsal time, structuring group work), interpretive language use (multimodal entry points, structuring reading) and communicative language use (modeling and multimodal output) intended to support students' ability to construct and communicate scientific understandings, not simply to reproduce the external forms of scientific language. Importantly, participants indicated they provided similar opportunities to multilingual learners and did not insist on language proficiency as a prerequisite to meaningful engagement in both the literacies and practices of science. These understandings were supported by their teacher education program, which employed a framework for effective multilingual learner instruction that stressed the importance of providing students rich opportunities for language use and engaging students in cognitively demanding work aligned with the NGSS.

In many ways, participants' understanding of scientific literacies aligned with the language-in-use perspective on language learning and the knowledge-in-use perspective of science learning advocated by science education scholars (Lee et al., 2019). This perspective advocates creating opportunities for students to learn language and science through meaningful engagement in science and engineering practices in social contexts rather than direct teaching of language structures or science content. In this respect participants are well-

positioned to support multilingual learners' acquisition of science literacies. However, there was one exception: Participants were less sure about how—or if—reading should play a meaningful role in science learning, a position that is not surprising given the tradition of textbook-based science instruction that is incompatible with contemporary approaches. However, teachers' understanding of the potential role of reading also seems grounded in a more traditional view of reading, one which privileges static models of text complexity and literal comprehension in the service of learning content from texts rather than the kinds of evaluative reading practices called for by the NGSS science and engineering practices.

One final point that cuts across all three language ideologies is the paucity of critical reflection. Again, it is important not to interpret these findings to mean participants do not have the capacity for critical reflection, given the kind of data upon which these findings are based. However, it does seem as if participants did not generally consider how their instructional practices served to disrupt or reproduce linguistic hierarchies in their classrooms. As I argued in my introduction, for teachers to go beyond equity as *access* to schooling and conceive of equity *transformation* of schools (Grapin, 2023, p. 1000), preservice teachers will need to develop sociolinguistic consciousness grounded in an awareness of language and power.

Limitations

There are three major limitations to this study that oblige my findings to be interpreted as a starting point for describing the interaction between preservice secondary science teachers' language ideologies, understanding of how to support the literacies and languages of science, and capacity for critical reflection. First, this study relies exclusively on interview data and would benefit from the incorporation additional, complementary types of

data. In particular, classroom observation data would provide more detailed, contextualized examples of how participants support literacy and language in their classes, including strategies that participants might not immediately think of as a form of literacy or language support. For example, one category of planned scaffolding involves the selection and sequencing of tasks (Hammond & Gibbons, 2005), but only a few participants mentioned anything like this as a form of support. Yet, it would be quite rare for a teacher not to deliberately and purposefully select and sequence tasks as part of their lesson planning. One possibility is that it is easier to name discrete strategies—for example, sentence frames, word walls, jigsaws, visuals—than to articulate how the organization of a lesson sequence supports literacy and language learning. In this case, it would be useful to pair classroom observations with post-observation interviews in which teachers could share their reasoning for their instructional decisions. Relatedly, the almost complete absence of critical reflection in my data could be partially attributable to the kind of data collected, as many participants might have found it difficult to provide thoughtful, critically reflective responses to interview questions in the moment; other kinds of data, such as written reflections, could have provided participants more time and space to consider their ideas and reflect on their experiences.

Second, this study only includes participants from one teacher education program, making it difficult to know the extent to which my findings are specific to teachers graduating from this particular program. This study could be strengthened by incorporating additional participants from other teacher education programs in order to explore which beliefs and reported practices might be typical of preservice secondary science teachers more generally and which might vary according to differences in teacher education program coursework or structure. Including additional participants from other programs would also

enable comparisons between monolingual and multilingual preservice science teachers; as there were only six multilingual participants in my study, I could not draw many conclusions about how participants' own linguistic backgrounds shaped their language ideologies or their understanding of effective support for multilingual learners. Similarly, including additional participants would also allow more robust comparisons between preservice science teachers who worked with multilingual learners in their field experiences—particularly if they worked with large numbers of newcomer students or students still institutionally classified as English learners—and teachers who did not. While many participants in my study had five or more reclassified students, few participants had more than a handful of classified English learners. With more participants representing a broader range of field experiences, it would be possible to examine the ways in which preservice teachers' beliefs and practices differed depending on their classroom experiences with multilingual learners.

Finally, this study only includes data collected at one point in time, neat the end of participants' teacher education program. Without longitudinal data, it is impossible to know how participants' beliefs and understandings manifest in practice once they are teaching full-time and subject to institutional pressures. As Cochran-Smith et al. (2016) note, most studies of preservice teachers fail to document how teachers' beliefs and understandings "enable them to navigate the complex tasks of teaching in the nation's increasingly diverse schools and classrooms, where there are strong accountability pressures that may compete with the ideas that candidates learned in their programs" (p. 514). For teachers of multilingual learners, there exist strong pressures to narrowly define the legitimate literacies and languages of science and to discount languages and language practices that do not match expectations of a monolingual academic language standard. Longitudinal data would help

clarify how preservice teachers' language ideologies, understandings of how to support multilingual learners, and capacity for critical reflection change as they move from the relative idealism of a teacher education program to confront the complex realities of teaching in an era defined by high-stakes testing and teacher accountability.

Discussion

First, my findings suggest that adopting a broad "language as resource" (Ruiz,1984) orientation is not enough to disrupt hegemonic monoglossic language ideologies. Even though monoglossic language ideologies were never part of the overt curriculum in their teacher education program and, in fact, participants were taught to value students' home languages, they nonetheless absorbed the dominant message that English language proficiency is the ultimate goal for multilingual learners. I have already discussed how monoglossic language ideologies can constrain the ways preservice secondary science teachers use students' home languages. But an even more fundamental consequence of the belief that English is the only language necessary for academic success is that multilingual learners will almost inevitably be defined by their needs instead of their strengths. One result is that teaching practices intended to support multilingual learners may inadvertently undermine their identities as skilled and capable language users and science learners. For example, in my findings, I noted that participants frequently positioned multilingual learners as needing help from their "more capable" peers. Although support from bilingual peers (and others) is valuable, if multilingual learners are always positioned as the receiver of language brokering and other translation services, they have limited opportunities "to publicly construct an 'able' student identity" (Lee et al., 2011).

Another outcome of these monoglossic language ideologies is that preservice secondary science teachers will focus on addressing the multilingual learners' individual learning needs rather grappling with systemic inequalities. This is absolutely understandable: teachers are held accountable for their students' academic performance, not for their willingness to challenge school orthodoxies. However, accepting English proficiency as the ultimate and only goal for multilingual learners only serves to reproduce linguistic hierarchies in the classroom and beyond. In contrast to accepting the monolingual status quo, establishing a translanguaging classroom in which students are encouraged to draw on all of their linguistic resources open up spaces for co-learning in which multilingual learners can be recognized for their linguistic expertise (García & Wei, 2014). Moreover, a translanguaging classroom, far from diluting rigorous, reform-oriented science instruction can in fact enhance it, by fostering a greater sense of inclusion and enhancing participation among students who might otherwise feel marginalized.

Second, my findings suggest that attention to supporting disciplinary literacies and languages must be complemented by attention to developing preservice secondary science teachers' sociolinguistic consciousness, including an "awareness of the sociopolitical dimensions of language use and language education" (Lucas and Villegas, 2013, p.101). Participants recognized that "academic language" was prioritized in school settings, and so at some level understood that some language varieties are valued over others. However, with a few exceptions, they tended not to question prevailing linguistic hierarchies or to make connections between these hierarchies and the marginalization of multilingual learners. Participants were not unaware of systemic inequalities: Many participants identified other school practices, such as tracking, that resulted in profoundly inequitable learning

opportunities for certain students, and some participants commented explicitly on the racialized nature of these practices. However, by and large, participants treated language as a neutral communication tool rather than as a way for dominant social groups to maintain their power through the accumulation of symbolic capital. Without a sociopolitical understanding of language—particularly in terms of how schooling reproduces social inequalities by privileging the standardized language varieties spoken by white, middle-class, monolingual English speakers—it is difficult to preservice secondary science teachers to engage in the kind of critical reflection I argue is necessary to disrupt harmful language ideologies. That is, critical reflection requires not just on a certain kind of disposition—a willingness to question one's own assumptions and practices—but also on sociolinguistic knowledge.

Implications

Keeping the limitations of this study in mind, below I suggest the implications of my research for practice, future research, and policy.

Practice

My findings suggest that teacher education programs must be more intentional about creating both ideological spaces and implementational spaces for heteroglossic understandings of bi/multilingualism (Flores & Schissel, 2014) and developing preservice secondary science teachers' sociolinguistic consciousness.

In the ideological space, teacher education coursework should focus on expanding preservice secondary science teachers' beliefs about and orientations towards language. In adopting a heteroglossic approach, teacher educators can normalize bi/multilingual language development and language practices, so that multilingual learners are understood on their own terms rather than in relation to an idealized native speaker; such approaches are critical

for monolingual preservice teachers but may be just as necessary for multilingual preservice teachers, who many have internalized negative evaluations of their own language practices. Heteroglossic approaches would go beyond highlighting the value of students' home languages for English language acquisition and science learning to emphasize the pedagogical and social justice values of creating translanguaging classrooms. At the same time, teacher educators can work to raise preservice teachers' sociolinguistic consciousness so that they are more attuned to issues of language and power as they play out in the secondary science classroom. Key to creating these ideological spaces is supporting preservice teachers to engage in critical reflection of their own beliefs about language and their own and their students' language practices. Teacher educators must also acknowledge the pressures of monoglossic language ideologies—which might be articulated by cooperating teachers, school and district policies, or even students themselves (Rutt & Mumba, 2023)—and equip preservice teachers with strategies for negotiating and resisting these pressures.

In implementational spaces, teacher education coursework should actively model ways of creating classrooms in which all students are encouraged and supported to draw on their full linguistic repertoires and facility with other semiotic resources. In helping preservice secondary science teachers envision and plan for such implementational spaces, it is critical that teacher educators foreground the disciplinary concerns of science teachers and acknowledge the very real constraints teachers will face in trying to disrupt monolingual or academic language ideologies. At the same time, teacher educators need not be solely responsible for modeling these new, more linguistically responsive approaches to supporting the languages and literacies of science; instead, teacher educators and preservice teachers can

work together to develop new approaches that are responsive to local contexts. Although such work is challenging, science-specific approaches to radically broadening the literacies and languages of science do exist (see, for example, Brown, 2016 and Emdin, 2011), as do practitioner-focused resources for creating translanguaging classrooms (see García & Wei, 2014). While such approaches may not be comfortable for all teachers or suitable for all teaching contexts, they can introduce preservice teachers to creative ways of reimagining the possibilities for language in a secondary science classroom. The outcome of such an approach will not be a set of standard tools for teachers to slip into their proverbial toolboxes but rather a flexible, resourceful approach to making space for their students' languages and language practices even in tightly constrained teaching contexts.

Theory

It should be clear by now that participants held an array of assumptions and beliefs about the kinds of language useful for learning and doing science, and that these language ideologies shaped the ways in which they supported their multilingual learners' engagement in the literacies and languages of science. Although researchers have proposed the constructs of pedagogical language knowledge (Bunch, 2013) and disciplinary linguistic knowledge (Turkan et al., 2014) to describe the specialized knowledge of language and literacy that mainstream content-area teachers should develop in order to engage multilingual learners in disciplinary learning, they have treated this knowledge base as if it is ideologically neutral when it is not. Theoretical accounts of what mainstream teachers need to know about language must go beyond understanding how language is used to construct and communicate disciplinary meaning to account for the ways language is establish or dismantle boundaries

between insiders and outsiders, maintain or disrupt linguistic hierarchies, and constrain or open up spaces for broader participation in disciplinary activity.

Future Research

Future research should address the three major limitations described in the previous section and incorporate the recommendations made there. In order to provide a more comprehensive description of how preservice secondary science teachers' language ideologies and beliefs are related to their classroom practices for supporting the languages and literacies of science, future studies should integrate interview data with other types of data, particularly classroom observation data. In order to capture preservice teachers' capacity for critical reflection, future studies will also need to provide participants adequate opportunities to engage in sustained reflection. Future studies should also draw on data from multiple sites in order to document differences and similarities across graduates from diverse teacher education programs and explore how contextual factors such as program structure, coursework, and values shape preservice teachers' developing beliefs and understandings. Relatedly, future research should include participants with a broader range of linguistic and ethnic/racial backgrounds in order to better understand how preservice secondary science teachers' own linguistic identities shape their beliefs and understandings. At the same time, such research is also a necessary corrective to the tendency in preservice teacher education research to focus on the needs of white, monolingual teachers and assume these align with the preparation needs of multilingual teachers and teachers of color (Cochran-Smith et al., 2016). Finally, future research should be longitudinal so that researchers can trace the ways in which preservice teachers' beliefs, understandings, and practices shift as they settle into the complexities of their profession. Ideally, future studies should not respond to each of

these proposals individually but should incorporate both interview and classroom observation data from preservice teacher participants enrolled in different teacher education programs and should follow these teachers into their first years of teaching.

Policy

It is important to recognize that while teachers have agency, they are working within the nested constraints of school, district, state, and national policies, including educational standards and testing regimes. Monoglossic language ideologies are intrinsic to the practices and mechanisms for defining and maintaining the category of "English learner" students, a situation heightened by accountability pressures to systematize assessment and classification schemes across states and maintain a consistent border between those students considered English learners and those deemed English proficient (Valdés, 2017). Bureaucratically, these borders are necessary in order for states to comply with the mandate, first instituted in the No Child Left Behind act of 2001, to monitor and report on the academic achievement of students belonging to the category of "English learner" students. Persistent disparities in academic achievement for English learners have in turn fueled attention to academic language as both an explanation for and a solution to multilingual learners' academic underachievement (see, for example, Bailey, 2007). The resulting emphasis on preparing teachers to support students' academic language development is in line with neoliberal reform efforts that assume educational equity can be achieved by providing access to high-quality instruction and, in the case of multilingual learners, access to normative, monolingual, standardized ways of using language (Cochran-Smith et al., 2016).

Even if teacher education programs are successful in disrupting potentially problematic language ideologies, cultivating a commitment to sociolinguistic justice in their

preservice teachers, and furnishing preservice teachers with tools to sustain these commitments in their practice, and providing a more equitable education for multilingual learners will require systems-level change.

Conclusion

In this study I have argued that it is important to approach preservice secondary science teachers' understanding of how to support the literacies and languages of science not just as a matter of pedagogical skills but as an ideological enterprise. I also argued for the potential of critical reflection as one way for preservice teachers to surface, interrogate, and disrupt language ideologies that marginalize the languages and language practices of multilingual learners and perpetuate linguistic—and frequently racial/ethnic—hierarchies. While this study is just a starting point for additional, more comprehensive research, it suggests how teacher education programs might start to leverage preservice science teachers' potential for growth by creating heteroglossic ideological and implementational spaces and complementing understanding of language structures with a broader sociolinguistic consciousness.

References

Athanases, S. Z., Banes, L. C., Wong, J. W., & Martinez, D. C. (2019). Exploring linguistic diversity from the inside out: Implications of self-reflexive inquiry for teacher education. *Journal of Teacher Education, 70*(5), 581–596. https://doi.org/10.1177/0022487118778838

Athanases, S. Z., & de Oliveira, L. C. (2014). Scaffolding versus routine support for Latina/o youth in an urban school: Tensions in building toward disciplinary literacy. *Journal of Literacy Research, 46*(2), 263–299. https://doi.org/10.1177/1086296X14535328

Bacon, C. K. (2018). "It's not really my job": A mixed methods framework for language ideologies, monolingualism, and teaching emergent bilingual learners. *Journal of Teacher Education, 71*(2), 172–187. https://doi.org/10.1177/0022487118783188

Baker-Bell, A. (2020). Dismantling anti-black linguistic racism in English language arts classrooms: Toward an anti-racist black language pedagogy. *Theory Into Practice, 59*(1), 8–21. https://doi.org/10.1080/00405841.2019.1665415

Bartolomé, L. (1994). Beyond the methods fetish: Toward a humanizing pedagogy. *Harvard Educational Review, 64*(2), 173–195. https://doi.org/10.17763/haer.64.2.58q5m5744t325730

Bazerman, C. (1988). *Shaping written knowledge: The genre and activity of the experimental article in science*. The University of Wisconsin Press.

Brinkmann, S. & Kvale, S. (2015). *Interviews: Learning the craft of qualitative research interviewing* (3rd ed.). Sage.

Brown, B. A. (2005). It isn't no slang that can be said about this stuff: Language, identity, and appropriating science discourse. *Journal of Research in Science Teaching, 43*(1), 96–126. https://doi.org/10.1002/tea.20096

Brown, B. A., Cooks, J., & Cross, K. (2016). Lyricism, identity, and the power of lyricism as the third space. *Science Education, 100*(3), 437–458. https://doi.org/10.1002/sce.21212

Bucholtz, M., Lopez, A., Mojarro, A., Skapoulli, E., VanderStouwe, C., & Warner-García, S. (2014). Sociolinguistic justice in the schools: Student researchers as linguistic experts. *Language and Linguistics Compass*, *8*(4), 144–157. https://doi.org/10.1111/lnc3.12070

Bunch, G. C. (2013). Pedagogical language knowledge: Preparing mainstream teachers for English learners in the new standards era. *Review of Research in Education*, *37*(1), 298–341. https://doi.org/10.3102/0091732x12461772

Bunch, G. C., & Martin, D. (2021). From "academic language" to the "language of ideas": A disciplinary perspective on using language in K-12 settings. *Language and Education, 35*(6), 539–556. https://doi.org/10.1080/09500782.2020.1842443

Bunch, G. C., Walqui, A., & Pearson, P. D. (2014). Complex text and new common standards in the United States: Pedagogical implications for English learners. *TESOL Quarterly*, *48*(3), 533–559. https://doi.org/10.1002/tesq.175

California Department of Education. (n.d.). Ed-Data.Org.

Cochran-Smith, M., Villegas, A. M., Whalen Abrams, L., Chávez-Moreno, L. C., Mills, T., & Stern, R. (2016). Research on teacher preparation: Charting the landscape of a

sprawling field. In D. Gitomer & C. Bell (Eds.), *Handbook of research on teaching* (pp. 439–548). American Educational Research Association.

Cummins, J. (2008). BICS and CALP: Empirical and theoretical status of the distinction. In B. Street & N. Hornberger, (Eds.), *Encyclopedia of Language and Education* (2nd ed., Vol. 2, Literacy, pp. 71–83). Springer. https://link.gale.com/apps/pub/1ZCN/GVRL?sid=bookmark-GVRL

de Jong, E. J., & Harper, C. A. (2005). Preparing mainstream teachers for English-language learners: Is being a good teacher good enough? *Teacher Education Quarterly*, *32*(2), 101–124.

Emdin, C. (2011). Dimensions of communication in urban science education: Interactions and transactions. *Science Education*, *95*(1), 1–20. https://doi.org/10.1002/sce.20411

Fang, Z. (2005). Scientific literacy: A systemic functional linguistics perspective. *Science Education*, *89*(2), 335–347. https://doi.org/10.1002/sce.20050

Fang, Z., Schleppegrell, M. J., & Cox, B. E. (2006). Understanding the language demands of schooling: Nouns in academic registers. *Journal of Literacy Research*, *38*(3), 247–273.

Flores, N. (2020). From academic language to language architecture: Challenging raciolinguistic ideologies in research and practice. *Theory Into Practice*, *59*(1), 22–31. https://doi.org/10.1080/00405841.2019.1665411

Flores, N., & Schissel, J. (2014). Dynamic bilingualism as the norm: Envisioning a heteroglossic approach to standards-based reform. *TESOL Quarterly*, *48*(3), 454–479.

Ford, M. (2008). Disciplinary authority and accountability in scientific practice and learning. *Science Education*, *92*(3), 404–423. https://doi.org/10.1002/sce.20263

Ford, M. J., & Forman, E. A. (2006). Redefining disciplinary learning in classroom contexts. *Review of Research in Education*, *30*(1), 1–32. https://doi.org/10.3102/0091732X030001001

García, O., & Li, W. (2014). *Translanguaging: Language, bilingualism and education*. Palgrave Macmillan. https://doi.org/10.1057/9781137385765

García, O., & Solorza, C. R. (2021). Academic language and the minoritization of U.S. bilingual Latinx students. *Language and Education*, *35*(6), 505–521. https://doi.org/10.1080/09500782.2020.1825476

Gibbons, P. (2015). *Scaffolding language scaffolding learning* (2nd ed.). Heinemann.

Grapin, S. E., Pierson, A., González-Howard, M., Ryu, M., Fine, C., & Vogel, S. (2023). Science education with multilingual learners: Equity as access and equity as transformation. *Science Education*, *107*(4), 999–1032. https://doi.org/10.1002/sce.21791

Halliday, M. A. K., & Martin, J. R. (1993). *Writing science: Literacy and discursive power*. University of Pittsburgh Press.

Hammond, J. & Gibbons, P. (2005). Putting scaffolding to work: The contribution of scaffolding in articulating ESL education. *Prospect*, *20*(1), 6–30.

Harris, S., Meier, V., & Arya, D. (in press). Reconstructing the academic in academic language: Radically listening to hidden worlds of knowledge building. In Silverman Andrews, O. & Tomlin, A. (Eds.), *When we hear them: Attuning teachers to language-diverse learners*. Information Age Publishing.

Heineke, A. J., Smetana, L., & Carlson Sanei, J. (2019). A qualitative case study of field-based teacher education: One candidate's evolving expertise of science teaching for

emergent bilinguals. *Journal of Science Teacher Education*, *30*(1), 80–100. https://doi.org/10.1080/1046560X.2018.1537058

Hinton, K. A. (2016). Call it what it is: Monolingual education in U.S. schools. *Critical Inquiry in Language Studies*, *13*(1), 20–45. https://doi.org/10.1080/15427587.2015.1124021

Irwin,V., De La Rosa, J., Wang, K., Hein, S., Zhang, J., Burr, R., Roberts, A., Barmer, A., Bullock Mann, F., Dilig, R., & Parker, S. (2022). *Report on the Condition of Education 2022* (NCES 2022-144). U.S. Department of Education.

Lemke, J. (2004). The literacies of science. In W. Saul (Ed.), *Crossing borders in literacy and science instruction: Perspectives on theory and practice* (pp. 33–47). International Reading Association.

Kaveh, Y. M. (2022). Beyond feel-good language-as-resource orientations: Getting real about hegemonic language practices in monolingual schools. *TESOL Quarterly*, *56*(1), 347–362. https://doi.org/10.1002/tesq.3053

Kibler, A. K., Salerno, A. S., & Andrei, E. (2023). Moving beyond language dichotomies in the education of multilingual students: Recontextualizing teacher resistance. *International Multilingual Research Journal*, *0*(0), 1–17. https://doi.org/10.1080/19313152.2023.2218789

Kozma, R., Chin, E., Russell, J., & Marx, N. (2000). The roles of representations and tools in the chemistry laboratory and their implications for chemistry learning. *Journal of the Learning Sciences*, *9*(2), 105–143. https://doi.org/10.1207/s15327809jls0902_1

Latour, B. (1999). Circulating reference. In *Pandora's hope: Essays on the reality of science studies* (pp. 24–79). Harvard University Press.

Lemmi, C., Brown, B. A., Wild, A., Zummo, L., & Sedlacek, Q. (2019). Language ideologies in science education. *Science Education*, *103*(4), 854–874. https://doi.org/10.1002/sce.21508

Lee, J. S., Hill-Bonnet, L., & Raley, J. (2011). Examining the effects of language brokering on student identities and learning opportunities in dual immersion classrooms. *Journal of Language, Identity & Education*, *10*(5), 306–326. https://doi.org/10.1080/15348458.2011.614544

Lee, O., Llosa, L., Grapin, S., Haas, A., & Goggins, M. (2019). Science and language integration with English learners: A conceptual framework guiding instructional materials development. *Science Education*, *103*(2), 317–337. https://doi.org/10.1002/sce.21498

Lee, O., Quinn, H., & Valdes, G. (2013). Science and language for English language learners in relation to Next Generation Science Standards and with implications for Common Core State Standards for English language arts and mathematics. *Educational Researcher*, *42*(4), 223–233. https://doi.org/10.3102/0013189x13480524

Lindahl, K., Fallas-Escobar, C., & Henderson, K. I. (2021). Linguistically responsive instruction for Latinx teacher candidates: Surfacing language ideological dilemmas. *TESOL Quarterly*, *55*(4), 1190–1220. https://doi.org/10.1002/tesq.3079

Liu, K. (2015). Critical reflection as a framework for transformative learning in teacher education. *Educational Review*, *67*(2), 135–157. https://doi.org/10.1080/00131911.2013.839546

Lucas, T., & Villegas, A. M. (2013). Preparing linguistically responsive teachers: Laying the foundation in preservice teacher education. *Theory Into Practice*, *52*(2), 98–109. https://doi.org/10.1080/00405841.2013.770327

Lyon, E. G., Stoddart, T., Bunch, G. C., Tolbert, S., Salinas, I., & Solis, J. (2018). Improving the preparation of novice secondary science teachers for English learners: A proof of concept study. *Science Education*, *102*(6), 1288–1318. https://doi.org/10.1002/sce.21473

MacDonald, R., Cook, H. G., & Miller, E. C. (2014). *Doing and talking science: A teacher's guide to meaning-making with English learners*. Board of Regents of the University of Wisconsin System.

Meier, V., Aminger, W., McLean, M., Carpenter, S. L., Moon, S., Hough, S., & Bianchini, J. A. (2020). Preservice secondary science teachers' understanding of academic language: Moving beyond "just the vocabulary." *Science Education*, *104*(2), 222–251. https://doi.org/10.1002/sce.21560

Michaels, S., & O'Connor, C. (2012). *Talk science primer*. TERC.

National Academies of Sciences, Engineering, and Medicine. (2018). *English learners in STEM subjects: Transforming classrooms, schools, and lives*. National Academies Press. https://doi.org/10.17226/25182

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. The National Academies Press.

Palmer, D., & Martínez, R. A. (2013). Teacher agency in bilingual spaces: A fresh look at preparing teachers to educate Latina/o bilingual children. *Review of Research in Education*, *37*, 269–297.

Ruiz, R. (1984). Orientations in language planning. NABE journal, 8(2), 15–34.

Rutt, A. A., & Mumba, F. M. (2020). Developing secondary pre-service science teachers' instructional planning abilities for language- and literacy-integrated science instruction in linguistically diverse classrooms. *Journal of Science Teacher Education*, *31*(8), 841–868. https://doi.org/10.1080/1046560X.2020.1760431

Rutt, A. A., & Mumba, F. (2022). Pre-service teachers' enactment of language- and literacy-integrated science instruction in linguistically diverse science classrooms. *Journal of Research in Science Teaching*, *59*(4), 619–655. https://doi.org/10.1002/tea.21739

Rutt, A.A., & Mumba, F. (2023). Examining preservice science teachers' implementation of language- and literacy-integrated science through a cultural historical activity theory lens. *Science Education*, *107*(3), 773–809. https://doi.org/10.1002/sce.21775

Schleppegrell, M. (2004). *The language of schooling: A functional linguistics perspective*. Lawrence Erlbaum Associates.

Smetana, L. K., Sanei, J. C., & Heineke, A. J. (2020). Pedagogical language knowledge: An investigation of a science teacher candidate's student teaching strengths and struggles. *Action in Teacher Education*, *42*(2), 149–166. https://doi.org/10.1080/01626620.2019.1650841

Snow, C. E. (2010). Academic language and the challenge of reading for learning about science. *Science*, *328*, 450–452.

Snow, C. E., & Uccelli, P. (2009). The challenge of academic language. In D. R. Olson & N. Torrance (Eds.), *The Cambridge Handbook of Literacy* (pp. 112–133). Cambridge University Press. https://doi.org/10.1017/CBO9780511609664.008

Strauss, A. & Corbin, J. (1994). Grounded theory methodology. In Denzin, N. & Lincoln, Y. (Eds.), *Handbook of Qualitative Research* (pp. 273–285). Sage Publications.

Thompson, G. A. (2021). Equitable education and the language ideological work of academic language (Introduction to special issue on academic language). *Language and Education*, *35*(6), 501–504. https://doi.org/10.1080/09500782.2021.1982964

Turkan, S., Oliveira, L. C. D., Lee, O., & Phelps, G. (2014). Proposing a knowledge base for teaching academic content to English language learners: Disciplinary linguistic knowledge. *Teachers College Record*, *116*(3), 1–35. https://doi.org/doi.org/10.1177/0161468114116003

Valdés, G. (2017). Entry visa denied: The construction of symbolic language borders in educational settings. In O. García, N. Flores, & M. Spotti (Eds.), *The Oxford Handbook of Language and Society* (pp. 321–348). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190212896.013.24

Valencia, R. R. (2010). The construct of deficit thinking. In *Dismantling contemporary deficit thinking: Educational thought and practice* (pp. 2–19). Routledge.

Valli, L. (1997). Listening to other voices: A description of teacher reflection in the United States. *Peabody Journal of Education*, *72*(1), 67–88.

Walqui, A. (2006). Scaffolding instruction for English language learners: A conceptual framework. *International Journal of Bilingual Education and Bilingualism*, *9*(2), 159–180.

Walqui, A. (2019). Designing the amplified lesson. In A. Walqui & G. C. Bunch (Eds.), *Amplifying the curriculum: Designing quality learning opportunities for English learners* (pp. 43–69). Teachers College Press.

Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A. S., & Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday sense-making. *Journal of Research in Science Teaching*, *38*(5), 529–552.

Windschitl, M., Thompson, J. J., & Braaten, M. L. (2018). *Ambitious science teaching*. Harvard Education Press.

Woolard, K. A. (2020). Language Ideology. In J. Stanlaw (Ed.), *The international encyclopedia of linguistic anthropology* (1st ed.). Wiley. https://doi.org/10.1002/9781118786093.iela0217

Appendices

Appendix A: Preservice Secondary Science Teacher Interview

Conceptions of Science Teaching

The first few questions are about your ideas about effective science teaching.

1) What do you think are the characteristics of an excellent science teacher?

2) What have you learned about effective science instruction from your teacher education program?
    a. What more would you like to learn or feel you need to learn about effective science instruction?

3) For the next few questions, imagine that you are teaching a secondary science course, for example, in your student teaching placement or when you have your own classroom.
    a. If an observer walked into your classroom, what do you hope the observer would notice about what you are doing as a teacher?
    b. What do you hope the observer would notice about the disciplinary core ideas, cross-cutting concepts, and/or science and engineering practices you are teaching?
    c. What do you hope the observer would notice about what the students are doing?
    d. How would you engage students in discussions?
    e. How would you engage students in reading and writing?
    f. What kinds of connections would you make between school science and students' lives outside of school?

Science Practices

These next few questions are about the *Next Generation Science Standards* science and engineering practices.

4) These are cards/a list with the eight science and engineering practices from the *NGSS* [at end of document].
    a. Which **two** have you implemented most often in your current student teaching placement? What are some examples of how these two practices have been implemented in your placement?

b. Out of all eight, which **one** do you think is most important to teach students? Why?
c. Which **one or two** practices do you think you need more help to understand or implement?

Conceptions of Learners

These next few questions are about students and student learning.

5) How do you think students learn science?

6) Why do you think some students succeed and other students struggle in school science courses?

7) Do you think students should be tracked according to ability in secondary science? What are the advantages and disadvantages of tracking?

Conceptions of Effective Practices for English Language Learners

These next few questions are about science instruction for diverse learners.

8) How prepared do you feel to teach in a culturally and linguistically diverse classroom?

9) How do you define an English language learner (ELL)?

10) How do you think ELL students differ from one another?

11) What do you think ELL students bring as resources to increase the richness in class?

12) What knowledge and skills do you think it takes to be an effective secondary science teacher of English Language Learners?

13) For the next few questions, imagine that you are teaching a secondary science class with English language learners as well as native English speakers, for example, in your student teaching placement.
    a. What supports for ELLs would you consider as you planned your instruction?
    b. What factors would you consider when developing or selecting science texts

for ELLs?

c. What would you consider when designing and using science assessment materials for ELLs?

Practicum/Student Teaching Experience

These questions are about your current practicum or student teaching placement.

14) In what school and in what classes are you currently placed?

15) In your placement, how aligned do you feel your teaching is to the *Next Generation Science Standards*?
    a. How much support do you feel you get to teach in ways that are aligned with the *NGSS*?

EdTPA

This final set of questions is about your edTPA teaching event.

16) For your edTPA, what was the topic of your lesson sequence?

17) In your edTPA lesson sequence …
    a. How did you address the *NGSS*?
    b. How did you support ELLs?
    c. In what ways did you engage students in discussions, reading, and/or writing?
    d. In what ways did you make connections between lesson activities and students' lives outside of school?

18) What kinds of support did you receive in completing your edTPA?
    a. What additional support would you have liked?

Wrap-Up

19) Just to let you know, for the next phase of our research, we would like to collect data about your experiences as a first-year teacher. This would involve completing another survey, participating in another interview, and submitting lesson plans and video recording yourself teaching a lesson series. You would receive a small financial compensation in appreciation for participating as a first-year teacher. You don't need to make a decision now, but we will contact you this summer or in the fall about your interest in participating.

Thank you!