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INVESTIGATING PRESERVICE SECONDARY SCIENCE AND MATHEMATICS TEACHERS' UNDERSTANDING OF MULTILINGUAL LEARNERS

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Abstract

This research is part of a larger ongoing research project focused on assessing the impact of undergraduate and graduate teacher preparation programs on preservice science and mathematics teachers. The author investigated preservice secondary science and mathematics teachers' (PSTs) understanding of MLs and how to teach them in reform-based ways. This study found that while PSTs largely expressed asset-based orientations to MLs, they continued to describe both MLs and effective instructional practices for MLs largely in terms of language development. Initial findings suggest that teacher education programs must carefully attend to the balance between supporting academic language and supporting rigorous content learning for MLs.

Keywords

Multilingual Learners (Mls), Equity, Science Education, Reform-Based Instruction, Pre-Service Teacher, Secondary Teacher Education

Introduction

Multilingual learners (MLs) account for more than nine percent of the students currently enrolled in K-12 classrooms in the U.S. (National Center for Education Statistics, 2016), prompting teacher education programs to focus more intently on preparing their preservice science and mathematics teachers to effectively teach MLs. These preservice teachers must move beyond general strategies to disciplinary-specific principles and practices (Lyon, Tolbert, Stoddart, Solis, & Bunch, 2016; Oliveira & Weinburgh, 2017) aligned with the *Next Generation Science Standards* (*NGSS,* NGSS Lead States, 2013) and the *Common Core State Standards in Mathematics* (*CCSS-M,* National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). They must also be able to use the diverse cultures, languages, and experiences of MLs as resources for disciplinary learning.

This study investigated preservice secondary science and mathematics teachers' (PSTs) understanding of MLs and how to teach them in reform-based ways. The 84 PSTs came from four universities in California, a state where 22% of public-school students are designated as MLs (California Department of Education, 2014). Initially, two research questions were addressed: How did PSTs define MLs? How did they understand effective instruction for MLs? The purpose of this study was to contribute evidence-based research to improve science and mathematics teacher education and help prepare PSTs to teach their discipline in reform-based ways to MLs.

Theoretical Framework

The theoretical framework is composed of three parts. The first dimension addresses teachers' knowledge and beliefs about MLs. Given that "teachers are both on the front line and responsible for the bottom line" in providing MLs with the knowledge, practices, and habits of mind needed to affiliate with and excel in science and mathematics, it is important to understand their views (Gandarà, Maxwell-Jolly, & Driscoll, 2005, p. 2). Previous research demonstrates that some teachers hold asset-based views of MLs while others maintain deficit-based ones. More specifically, a substantial number of studies show that at least some teachers hold high expectations for MLs (Buxton, Carlone, & Carlone, 2005; Cahnmann & Remillard, 2002; Johnson, Bolshakova, & Waldron, 2016).

Several indicate that at least some teachers also recognize MLs as a diverse rather than homogeneous group (Bartell et al., 2010; Buck, Mast, Ehlers, & Franklin, 2005). Additional studies demonstrate that some teachers view MLs as bringing valuable knowledge and experiences to the classroom (Moore, 2008; Ortega, Luft, & Wong, 2013); as entitled to rich learning opportunities and adequate supports (Chval, Pinnow, & Thomas, 2015; de Araujo, I, Smith, & Sakow, 2015); as enriching the classroom for all students (Buck et al., 2005; Polat & Mahalingappa, 2013); and as potential scientists and mathematicians (Carlone, Haun-Frank, & Webb, 2011; Tolbert & Knox, 2016).

However, deficit-based views about MLs are also common. Several studies document the low expectations some teachers hold for MLs' success **(**Buxton, 2005; de Araujo, Smith, & Sakow, 2016). Others indicate that some teachers believe MLs are homogeneously low in language proficiency and STEM, conflating English language proficiency with STEM content understanding (Cho & McDonnough, 2009; Harklau, 2000; Wilson, Sztajn, Edgington, Webb, & Myers, 2017). And still others describe some teachers holding stereotypes of MLs grounded in their first language, ethnicity, and/or country of origin (Chval & Pinnow, 2010; de Araujo, 2017) and/or as understanding MLs to lack relevant prior knowledge, experiences, and/or language (Deaton, Deaton, & Koballa, 2014; Lee, Maerten-Rivera, Buxton, Penfield, & Secada, 2009).

A second dimension of this conceptual framework addresses the need for teachers to adopt a principle-based approach to supporting MLs. The framework employed consists of five principles. One principle, *providing students with cognitively demanding work* (Windschitl, Thompson, & Braaten, 2018), insists that MLs routinely engage in the types of reform-minded, academically rigorous tasks that are often reserved for non-ML students (Iddings, 2005). A second principle, *providing students opportunities for rich language and literacy exposure and practice* (Lee, Quinn, & Valdés, 2013; Moschkovich, 2007), holds that MLs must be given extensive opportunities to engage in the discourse of science and mathematics. A third principle, *identifying academic language demands and supports for MLs* (Aguirre & Bunch, 2012), emphasizes that teachers must scaffold the academic language demands of their classrooms. A fourth principle, *building on and using students' funds of knowledge and resources* (Moll, Amanti, Neff, & Gonzalez, 1992), asks teachers to use MLs' languages, experiences, and community connections as resources for learning. Finally, the fifth principle, *creating a safe classroom community*, encourages teachers to establish classroom norms and routines that facilitate engagement in reasoning and sense-making (Windschitl, Thompson, & Braaten, 2018; Rosebery, Ogonowski, DiSchino, & Warren, 2010).

A third dimension is a situated theory of teacher learning. A situated theory considers all learning to occur in a context and for that context, associated activity, and tools to contribute to what is learned (Brown, Collins, & Duguid, 1989; Greeno, 2006; Putnam & Borko, 2000). It also understands learning to be developed through social interactions: Learning is conceptualized as increased participation in a community's practices as well as an individual's development as a result of this participation (Borko, 2004; Lave & Wenger, 1991; Putnam & Borko, 2000; Sawyer, 2006). Because teacher learning is situated in communities, colleagues can either help each other to develop a more profound understanding of content and instructional practices or constrain efforts to enact equity-minded and reform-based instruction (Putnam & Borko, 2000).

Methodology

This study is part of a larger ongoing research project focused on assessing the impact of undergraduate and graduate teacher preparation programs on preservice science and mathematics teachers. To date, the larger project has collected initial and follow-up surveys, initial and follow-up interviews, and teacher assessment portfolios for two cohorts of preservice science and mathematics teachers at six teacher education programs based in California research universities. This study uses follow-up interviews with PSTs (*n*=84) from four universities; the two universities that did not have complete data sets for at least 10 PSTs in at least one of the two years were excluded. At three of the universities included in this paper, participants were enrolled in small, 13-month, post-baccalaureate teacher education programs; at the fourth, they were undergraduates enrolled in an experimental, fourth-year program. Table 1 shows the distribution of participants across the four campuses, while Table 2 presents demographic information.

Table 1

Distribution of PST Participants Across Four Campuses

	Year 1	Year 2	Total
University 1	16	14	30
University 2	14	10	22
University 3	14	N/A	14
University 4	N/A	19	20
			86

Table 2
Participant Demographics

Discipline	
Science	68%
Mathematics	32%
Gender	
Female	65%
Male	35%
Race/Ethnicity	
White/European American	60%
Asian/Asian American	15%
Other	12%
Multiracial	7%
Latinx	3%
Pacific Islander	3%
First Language	
English	83%
Language(s) other than or in addition to English	17%

Note. All demographic data are self-reported.

The follow-up interviews included approximately 20 open-ended questions designed to elicit PSTs' conceptualizations of reform-based science or mathematics teaching, in general, and the teaching of culturally and linguistically diverse students, in particular. Each audio-recorded interview lasted approximately one hour. Interviews were professionally transcribed, checked by members of the research team for accuracy, and then qualitatively coded across two cycles of analysis. In both cycles, the unit of analysis was a natural meaning unit (Brinkmann & Kvale, 2015, p. 235), a collection of statements related to the same central meaning. In the first cycle, the author used *a priori* codes derived from the literature on effective ML instruction and research questions. In the second cycle, emergent codes (Strauss & Corbin, 1994) that became relevant during data analysis were used. The full set of codes is summarized in Table 3.

Table 3 *Codes Used in Analysis*

Misunderstood question	PST seems to have misunderstood the interviewer's question.
PST understanding of MLs	
Contributions of ML students	PST recognizes contributions MLs make to their classrooms.
Deficit understanding of ML students	This code should typically be used in conjunction with the child codes under "definition of ML students." PST focuses on what ML students (or their families) lack, or describe students as problems.
Diversity of ML students	PST recognizes that MLs are a heterogeneous group. This code
	should typically be used in conjunction
Definitions of ML students	PST describes ML students in terms
• All students are MLs	…their similarity to other students. PST comments that all students and/or teachers are actually
• An individual like any other	…their individuality as human beings. PST comments that MLs
	are different from each other in the same
• Cultural diversity and/or intercultural exchange	…being culturally diverse in a general sense (i.e., not in terms
	of home language or nationality) or
• Different perspective on content	…bringing a different perspective on math/science (e.g., a
• English language proficiency	PST describes MLs as still being in the process of learning
• Home language	…differences in their home language, including the language
	itself or students' proficiency or literacy

• Math or science	…differences in math or science
• Race, ethnicity, nationality	…a particular race, nationality, or, ethnicity, including
• Needs support or struggling student	…the support they need or the learning challenges.
• Personal qualities	…their personality (e.g., extroversion) or personal attributes
• Prior knowledge or schooling	…their prior schooling, including their academic preparation for math/science and their literacy levels in
• Proficiency in everyday v. academic English	…their proficiency with informal or conversational language
• Proficiency in different modes of communication	…their proficiency across different modes of communication
• Proficiency in other dialects v. "standard"	…their proficiency in speaking a regional or ethnic dialect (e.g., AAVE) v. "standard" English.
• SES	…their socioeconomic class.
• Values or priorities	…their values and priorities, such as investment in school or in
PST understanding of how to support MLs	
Attending to equity for MLs	PST describes the importance of providing equitable opportunities for MLs to participate, access content, etc.
Confidence (or lack of) in teaching MLs	PST describes how prepared they feel to teach MLs or culturally and linguistically diverse students in general.
Content v. language teaching or learning	PST differentiates between language and content learning in terms of the support they provide, the purpose of this support, and/or the focus of their teaching.
Deficit perspective on teaching MLs	PST focuses on the problems MLs cause for their teaching.
Dimension of instruction	PST describes making modifications in relation to
• Assessments	…formative or summative assessments.
• Planning	…planning lessons.
• Texts	…selecting or using written texts.
• Teaching	…teaching.
Five principles	PST describes providing MLs
Academic language demands	…supports to scaffolding academic language demands at the vocab, syntax, or discourse level.
Cognitively demanding tasks	… opportunities to engage in rigorous, standards-aligned tasks.
Funds of knowledge	… opportunities to draw on their experiences, interests, languages, cultures, or community connections.
Language opportunities … opportunities to en	… opportunities to engage with oral or written discourse.
Safe classroom community	…norms and routines that support sense-making.

To answer the first research question, the most frequent descriptors PSTs used to define MLs were identified, in particular, their diversity and their potential contributions. To answer the second question, the author examined the relative prominence PSTs gave to each of the five principles of effective teaching and the purpose of the supports they indicated they had or would use to modify instruction for MLs.

Findings

RQ 1: How Did PSTs Understand ML Students?

Overall, PSTs' understanding of MLs could be organized into three themes: (1) linguistic needs; (2) diversity; and (3) classroom contributions. First, PSTs typically defined MLs as students who were still learning English. Many added that MLs were in the process of learning *academic* English, as opposed to everyday English. As one participant stated: "I would define [an] ML as a student that is still learning their English. I would say more so academic English than just spoken English." A small number of participants emphasized that MLs were learners just like any other student—that all students were multilingual learners. For example, one participant said: "I feel like basically all of my students are multilanguage learners. Because, there are tiers of English." PSTs also recognized diversity among MLs. Most noted differences in ML's home language, language support needs, and cultures. They also reported differences in MLs' academic preparation and proficiency across different language modalities such as speaking, reading, and writing. Finally, PSTs recognized MLs' potential contributions. Many discussed how MLs contributed cultural diversity and opportunities for intercultural exchange. Some PSTs also suggested MLs served as a resource for language development. Finally, some PSTs recognized that MLs could bring a different perspective on disciplinary concepts and so could help their classmates relate to the content in different ways. One participant explained:

There are five different ways to find the area of a sector of a circle. And it's possible that while I may teach one of those ways, a multilanguage learner wouldn't really understand what I'm doing and they have to do it on their own, coming up with a completely new method. And they get to share that method with other students.

RQ 2: How Did PSTs Understand Effective Instruction for ML Students?

Here the author sought to identify how PSTs' understanding of effective instruction for MLs mapped onto the five principles of the framework described in the Theoretical Framework. Initial results indicated that when describing how they had or would modify their instruction to support MLs, PSTs focused overwhelmingly on one principle: scaffolding academic language demands. All PSTs described adjusting their instruction or materials so that ML students had access to comprehensible input and were not overwhelmed by unnecessary language demands. A majority of PSTs also referred to using supports to help MLs produce written and oral language. Many of these PSTs suggested that such supports could help MLs communicate their content understanding independent of language constraints, but they were less likely to suggest these supports could help MLs produce the complex oral and written language characteristic of mathematics and science discourse. In terms of the remaining four principles, a substantial number of PSTs also spoke about the value of providing MLs rich language opportunities, particularly in the form of peer collaboration. Notably, few PSTs described effective instruction for MLs in relation to drawing on students' funds of knowledge, creating a safe classroom community, or engaging MLs in cognitively demanding tasks. These findings suggest that the two principles directly related to language understanding and use are most salient to the PSTs in this study.

Conclusion

In closing, this study provides evidence-based research in a post-truth era to clarify how preservice secondary science and mathematics teachers define and support their ML students. This study indicated that while PSTs largely expressed asset-based orientations to MLs, they continued to describe both MLs and effective instructional practices for MLs largely in terms of language development. While such attention to language is both understandable and important, the current principle-based framework argues that teachers must do more.

These findings suggest that teacher education programs must carefully attend to the balance between supporting academic language and supporting rigorous content learning for MLs. Otherwise, they risk graduating beginning teachers relatively skilled in managing language demands but without a comparable understanding of how to foster more complex conceptual and hence linguistic development.

References

Aguirre, J. M., & Bunch, G. C. (2012). What's language got to do with it?: Identifying language demands in mathematics instruction for English language learners. In S. Celedón-Pattichis & N. Ramirez (Eds.), *Beyond good teaching: Advancing mathematics education for ELLs* (pp. 183-194). Reston, VA: National Council of Teachers of Mathematics

Bartell, T. G., Foote, M. Q., Aguirre, J. M., Roth McDuffie, A., Drake, C., & Turner, E. E. (2010). Preparing preK-8 teachers to connect children's mathematical thinking and community based funds of knowledge. In P. Brosnan, D. B. Erchick, & L. Flevares (Eds.), *Proceedings of the 32nd annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 1183-1191). Columbus, OH: The Ohio State University.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain.*Educational Researcher, 33*(8), 3-15. doi:10.3102/0013189X033008003

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning.*Educational Researcher, 18*(1), 32-42. doi:10.3102/0013189X018001032

Buck, G., Mast, C., Ehlers, N., & Franklin, E. (2005). Preparing teachers to create a mainstream science classroom conducive to the needs of English-language learners: A feminist action research project. *Journal of Research in Science Teaching, 42*(9), 1013–1031. doi:10.1002/tea.20085

Buxton, C. A. (2005). Creating a culture of academic success in an urban science and math magnet high school. *Science Education, 89*(3), 392–417. doi:10.1002/sce.20057

Buxton, C. A., Carlone, H. B., & Carlone, D. (2005). Boundary spanners as bridges of student and school discourses in an urban science and mathematics high school. *School Science and Mathematics, 105*(6), 302–312. doi:10.1111/j.1949-8594.2005.tb18131.x

Cahnmann, M. S., & Remillard, J. T. (2002). What counts and how: Mathematics teaching in culturally, linguistically, and socioeconomically diverse urban settings. *The Urban Review,34*(3), 179-204. doi:10.1023/A:1020619922685

California Department of Education. (2014). *CalEdFacts*. Retrieved from http://www.cde.ca.gov/re/pn/fb/index.asp

Carlone, H. B., Haun-Frank, J., & Webb, A. (2011). Assessing equity beyond knowledge- and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching, 48*(5), 459–485. doi:10.1002/tea.20413

Cho, S., & McDonnough, J. T. (2009). Meeting the needs of high school science teachers in English language learner instruction. *Journal of Science Teacher Education*, 20(4), 385-402. doi:10.1007/s10972-009-9136-9.

Chval, K. B., & Pinnow, R. J. (2010). Pre-service teachers' assumptions about Latino/a Englishlanguage learners in mathematics. *Teaching for Excellence and Equity in Mathematics*, *2*(1), 6-12.

Chval, K. B., Pinnow, R., & Thomas, A. (2015). Learning how to focus on language while teaching mathematics to English language learners: A case study of Courtney. *Mathematics Education Research Journal, 27*(1), 103-127. doi:10.1007/s13394-013-0101-8

de Araujo, Z. (2017). Connections between secondary mathematics teachers' beliefs and their selection of tasks for English language learners. *Curriculum Inquiry*. Advanced online publication. doi:10.1080/03626784.2017.1368351

de Araujo, Z., I, J. Y., Smith, E., & Sakow, M. (2015). Preservice teachers' strategies to support English learners. In T. G. Bartell, K. N. Bieda, R. T. Putnam, K. Bradfield, & H. Dominguez (Eds.), *Proceedings of the 37th annual meeting for the North American Chapter for the Psychology of Mathematics Education* (pp. 648–655). East Lansing, MI.

de Araujo, Z., Smith, E., & Sakow, M. (2016). Reflecting on the dialogue regarding the mathematics education of English learners. *Journal of Urban Mathematics Education, 9*(2), 33-48.

Deaton, C. C. M., Deaton, B., & Koballa, T. (2014). Teachers' awareness of their diverse classrooms: The nature of elementary teachers' reflections on their science teaching practice. *Action in Teacher Education, 36*(3), 211-233. doi:10.1080/01626620.2014.917363

Gandarà, P., Maxwell-Jolly, J., Driscoll, A. (2005). *Listening to teachers of English language learners: A survey of California teachers' challenges, experiences, and professional development needs*. Santa Cruz, CA: Policy Analysis for California Education.

Greeno, J. G. (2006). Learning in activity. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 79-96). New York, NY: Cambridge University Press.

Harklau, L. (2000). From the "good kids" to the "worst": representations of English language learners across educational settings. *TESOL Quarterly, 34*(1), 35–67. doi:10.2307/3588096

Iddings, A. C. D. (2005). Linguistic access and participation: English language learners in an English-dominant community of practice. *Bilingual Research Journal*, *29*(1), 165-183 http://dx.doi.org/10.1080/15235882.2005.10162829

Johnson, C. C., Bolshakova, V. L. J., & Waldron, T. (2016). When good intentions and reality meet: Large-scale reform of science teaching in urban schools with predominantly Latino ELL students. *Urban Education*, 51(5), 476-513. doi:10.1177/0042085914543114.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* NewYork, NY: Cambridge University Press.

Lee, O., Maerten-Rivera, J., Buxton, C., Penfield, R., & Secada, W. G. (2009). Urban elementary teachers' perspectives on teaching science to English language learners. *Journal of Science Teacher Education, 20*(3), 263-286. doi:10.1007/s10972-009-9133-z

Lee, O., Quinn, H., & Valdés, G. (2013). Science and language for English languagelearners 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. doi:10.3102/0013189X13480524

Lyon, E. G., Tolbert, S., Stoddart, P., Solis, J., & Bunch, G. C. (2016). *Secondary science teaching for English learners: Developing supportive and responsive learning contexts for sense-making and language development.* New York, NY: Rowman & Littlefield.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and schools. *Theory into Practice*, *31*(2), 132-141.

Moore, F. M. (2008). The role of the elementary science teacher and linguistic diversity. *Journal of Elementary Science Education, 20*(3), 49-61. doi.org/10.1007/BF03174708

Moschkovich, J. (2007). Using two languages when learning mathematics. *Educational Studies in Mathematics*, *64*(2), 121-144.

National Center for Education Statistics. (2016). *English language learners in public schools*. Retrieved from https://nces.ed.gov/programs/coe/indicator_cgf.asp

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common core state standards*. Washington, DC: Authors.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Retrieved from http://www.nextgenscience.org/next-generation-science-standards

Oliveira, A., & Weinburgh, M. (Eds.). (2017). *Science teacher preparation in content-based second language acquisition*. Dordrecht, the Netherlands: Springer.

Ortega, I., Luft, J. A., & Wong, S. S. (2013). Learning to teach inquiry: A beginning science teacher of English language learners. *School Science and Mathematics, 113*(1), 29-40. doi:10.1111/j.1949-8594.2013.00174.x

Polat, N., & Mahalingappa, L. (2013). Pre- and in-service teachers' beliefs about ELLs in content area classes: A case for inclusion, responsibility, and instructional support. *Teaching Education*, 24(1), 58-83. doi:10.1080/10476210.2012.713930.

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4-15. doi:10.3102/0013189X029001004

Rosebery, A. S., Ogonowski, M., DiSchino, M., & Warren, B. (2010). "The coat traps all your body heat": Heterogeneity as fundamental to learning. *Journal of the Learning Sciences, 19*(3),322 – 357. http://dx.doi.org/10.1080/10508406.2010.491752

Sawyer, R. K. (2006). The new science of learning. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 1-16). New York, NY: Cambridge University Press.

Tolbert, S., & Knox, C. (2016). "They might know a lot of things that I don't know": Investigating differences in preservice teachers' ideas about contextualizing science instruction in multilingual classrooms. *International Journal of Science Education, 38*(7), 1133-1149. doi:10.1080/09500693.2016.1183266

Wilson, P. H., Sztajn, P., Edgington, C., Webb, J., & Myers, M. (2017). Changes in teachers' discourse about students in a professional development on learning trajectories. *American Educational Research Journal, 54*(3), 568-604. doi:10.3102/0002831217693801

Windschitl, M., Thompson, J., & Braaten, M. (2018). *Ambitious science teaching*. Cambridge, MA: Harvard University.