PRE-SERVICE TEACHERS' DEVELOPING INSTRUCTIONAL STRATEGIES FOR ENGLISH LANGUAGE LEARNERS IN SECONDARY MATHEMATICS

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This study describes the knowledge and skills pre-service teachers (PSTs) identify as important for teaching secondary mathematics to ELLs before and after their credential program. Preliminary results show that most of the PST's (73%) initially described knowledge and skills globally with few specifics on implementation. During follow-up nearly half (45%) of the PSTs described more organized and specific ways to support learning for ELLs. Secondary analysis reveals various approaches to supporting ELLs, including 1) making mathematics accessible, 2) treating everyday language and experiences as resources, and 3) "engag[ing] students in mathematical practice" (Moschkovich, 2013, p. 49).

Keywords: Teacher Education-Preservice, Teaching Tools and Resources, Equity and Diversity

This study is part of a larger research project, Science and Mathematics Teacher Research Initiative (SMTRI), which seeks to explore novice secondary school teachers' beliefs, knowledge, and skills to provide effective mathematics instruction to culturally and linguistically diverse students. Participants in SMTRI are graduates of the Cal Teach program representing five UC campuses. This study is concerned with a subset of data from one campus. Previous research has documented that many teachers feel underprepared to teach mathematics to English language learners (ELLs) (de Araujo, Roberts, Willey, & Zahner, 2018). Therefore, this study identifies the ways pre-service teachers (PSTs) take up and develop ideas and practices for supporting ELLs in secondary mathematics classes. This study explores the research question: in a credential program that emphasizes the integration of content and language instruction, do PSTs ideas about knowledge and skills related to teaching ELLs change? If so, how?

Conceptual Framework

Research-based guidelines for equitable mathematics teaching practices for English Language Learners (Moschkovich, 2013) framed the analysis of the interviews. In particular, we considered the following guidelines because of their alignment with aspects of the SMTRI intervention: Engage students in the eight CCSS for mathematical practice, Keep tasks focused on high cognitive demand, conceptual understanding, and connecting multiple representations, Facilitate students' production of different kinds of reasoning, and Focus on language as a resource for reasoning, sense-making, and communicating with different audiences for different purposes (Moschkovich, 2013).

The study framed the development of teaching practices with a teacher development learning progression that describes a trajectory through four stages and considers the integration of English language development alongside content learning: 0 = *Not Present* (Rule-based or inflexible view of teaching practices), 1 = *Introducing* (global approach to teaching practices), 2 = *Implementing* (organized, planned approach to teaching practices, which includes probing, scaffolding, or connections to students' experience), and 3 = *Elaborating* (teaching practices are flexible and responsive to context) (Adapted from Stoddart, Pinal, Latzke, & Canaday, 2002).

Methods

Participants in this study include 11 PSTs from two cohorts in a single-subject master-credential program for mathematics from one of the five UC campuses. Each participant was interviewed at the

In: Sacristán, A.I., Cortés-Zavala, J.C. & Ruiz-Arias, P.M. (Eds.). (2020). *Mathematics Education Across Cultures: Proceedings of the 42nd Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, Mexico. Cinvestav / AMIUTEM / PME-NA. https:/doi.org/10.51272/pmena.42.2020

beginning and end of their credential program. For this study, the authors solely focused on the sections and questions that were specifically related to ELLs.

Interviews were initially coded using a rubric adapted from the Math Classroom Observation Rubric (MCOR) (see Stoddart, Pinal, Latzke, & Canaday, 2002). The MCOR was developed to characterize mathematics teacher instruction in alignment with the Common Core State Standards. The MCOR characterizes four aspects of teacher practice and pedagogy: 1) mathematics sense-making through applied math/engineering practices, 2) mathematics discourse, 3) English language and literacy development, and 4) contextualized mathematics activity. For each of these categories, the interviews were coded on a scale of 0-3. Differences in scores on pre- and post-interviews were then evaluated to determine changes in participants' responses. Interviews were coded by both authors and scores were calibrated to reach 100% inter-rater agreement. Secondary analysis of the interviews included purposeful selection of four PSTs within three categories: 1) highest overall scores, 2) most improved scores, and 3) scores that decreased. The interviews from these four PSTs served as case studies for more in-depth analysis.

Results

Increased Implementation

During the initial interview, most of the PST's (73%) described knowledge and skills globally with little to no specifics on implementation. For instance, 7 out of 11 PSTs identified using "multiple representations" to support ELLs yet did not explain how or why they would use multiple representations. One PST said, "I think multiple means of representation and having multiple points of access of information at the same time." Another PST similarly explained,

> It's kind of the same supports that you use working with all types of students with IEPs is or just different learning types or abilities. It's the UDL lesson plan with the multiple modes of representation and engagement and expression. You're just trying as many different things as possible to try to activate learning and understanding within all your students. (Transcript, 2020)

During the follow-up, nearly half (45%) of the PSTs described more organized and specific ways to support mathematics learning for ELLs. Out of the eight participants who scored a "1" during their initial interview, two participants increased their scores by one point and two participants increased their scores by two. One participant scored a "2" on their initial interview and improved by one point. One participant's score decreased by one point.

Among participants who described more organized and specific plans for supporting ELLs, general ideas that were discussed initially became more organized and flexible. Illustrating this, one PST mentioned giving students time to practice language during mathematics instruction: "I think group work and discussing among peers is important as well because I think another important part of language development comes from talking and listening [...] so they all have to have that practice of using that academic language." In the follow-up interview, the same PST elaborated upon this idea of "practice" through their descriptions of having ELLs practice in a "safe way" and giving students opportunities to practice discourse in a "low-stakes environment" by using think-pair-shares and reflections. This PST then described, "in a math classroom you are trying to get the math across and not be so worried about that their response isn't in perfect English to you, but that they understand the mathematical concepts that are happening." Other PSTs discussed similar ideas across their pre- and post-interviews (e.g. multiple representations, getting to know the students, supporting practice with math and language, etc.) and the description of these descriptions often became more specific and organized during the follow-up.

Various Approaches to Supporting ELLs

Secondary analysis of PSTs with the most improvement and the highest overall score reveals various approaches to supporting ELLs. Approaches that emerged across the focal cases include 1) making mathematics accessible, 2) treating everyday language and experiences as resources, and 3) "engage students in mathematical practice" (Moschkovich, 2013, p. 49).

Making mathematics accessible. Across the three focal cases, each PST identified ways of making mathematics accessible. Case Study 1 (CS1) discussed getting to know where students came from including their "culture" and "home language" with the rationale that knowing this information supports "students [to] see themselves being involved in the curriculum and being involved in the classroom and that their language is validated and their culture is validated." Other ways CS1 discussed making mathematics accessible included using "discovery learning", supporting "students' understanding of a concept before introducing the term", using a familiar "context", and drawing on "peers" as resources to support learning. Similarly, Case Study 2 (CS2) discussed the idea of facilitating "practice" with mathematics and language. Initially CS2 described "practice" in terms of "talking and listening" and reasoned that students need "to practice their language skills." During the follow-up, CS2 discussed "practice" with more organization and flexibility. CS2 discussed the importance of practicing mathematics and language in a "low stakes environment" with peers and with the guidance of other instructional supports such as "think-pair-shares" and "personal reflection." CS2 stressed the idea that mathematics should be the focus, not correctness of vocabulary, as students are making meaning for concepts. Moreover, CS2 acknowledged that students need time "to process and think."

Treating everyday language and experiences as resources. An approach that consistently emerged across the focal cases included treating everyday language and students' experiences as resources for learning. Illustrating this, Case Study 3 (CS3) described drawing on various perspectives, bringing in context from students' "home lives that relate[s] to the subject matter," and being "flexible" with instruction. Further, CS3 discussed giving students various opportunities to draw on familiar context and their linguistic resources to develop conceptual understanding while supporting increased precision with ideas and terminology. CS3 mentioned, "If students are able to informally talk to each other about concepts and their initial ideas, then they can get more and more precise [...with] explaining, justifying their ideas." CS3 focused on ideas related to contextualizing mathematics activities in a way that reflects the lives and resources that ELLs bring with them to the classroom. Similarly, CS1 elaborated upon the idea that students should use be able to use their home language to support understanding when they described,

> Because mathematics requires students to explain one's thinking a lot of the times, if students bring to the class more proficiency in another language, then using that language to explain mathematical thinking and to process and to think is a really, really great way for them to build conceptual understanding. (Transcript, 2020)

In line with an elaborated view of instructional practices, the focal cases explicitly discussed connections to students' lives and activities and discussed language as a resource.

"Engage students in mathematical practice" (Moschkovich, 2013, p. 49). Two of the three focal cases identified teaching techniques that made explicit connections to supporting students' engagement in mathematical practices. Such techniques included attending to reasoning, eliciting justification and explanations, supporting negotiating, and supporting precision. CS3 described their approach to teaching as trying to uncover the "thinking behind it" as they talked about engaging with ELLs. Specifically, CS3 discussed giving assessments to ELLs where students could "come in and just talk to me and explain verbally or, you know, with a sketch." CS3 talked about creating a classroom culture where students "informally talk to each other about concepts and their initial ideas, then they can get more and more precise." These ideas reflected attending to the reasoning, not the correctness of vocabulary, while supporting students to gradually move towards precision of ideas and vocabulary. In a similar fashion, CS1 described modeling justifications and explanations and supporting students in this practice. As they explained, "you're constructing viable arguments that enforces a lot of communication and when you're communicating about your ideas and when you're defending your answers and you can explain something, that's when you really get a strong grasp on understanding the concept behind things." These two PST discussed instructional strategies that reflect an understanding of the mathematical practices as well as concrete ways of supporting engagement with the practices specific for ELLs.

Discussion

Specific approaches to mathematics instruction for ELLs emerged as a part of the secondary analysis of the focal cases. These approaches include: 1) making mathematics accessible, 2) treating everyday language and experiences as resources, and 3) "engage students in mathematical practice" (Moschkovich, 2013). These approaches align with other works looking at mathematics teaching and ELLs (e.g. Bunch, 2014; Moschkovich, 2013) that can be enacted by monolingual and multilingual teachers. Moschkovich (2013) highlights the importance of supporting mathematical reasoning, conceptual understanding, and discourse and broadening participation for ELLs in mathematics classes. Further, "to support mathematical reasoning, conceptual understanding, and discourse, classroom practices need to provide all students with opportunities to participate in mathematical activities that use multiple resources to do and learn mathematics" (Moschkovich, 2013, p. 46). The approaches that were discussed by the focal cases in this study reflect alignment with these. The consistency of these practices and explicit references to classes and professors throughout the interviews suggest that these PST are taking up and developing the ideas that were presented to them during their credential program. Since improvement was not consistent across PSTs, and one PST scored lower on the follow-up interview, this work also shows that other factors (beyond the scope of this study) may contribute to the ideas PST have about mathematics instruction with ELLs. This has implications for PST education that future teachers may need additional support, outside of the classes they are taking, to fully develop strategies for supporting ELLs in secondary mathematics. PSTs in secondary mathematics would benefit from additional efforts by Cal Teach and credential programs to examine the role of language when learning mathematics and reflect on beliefs about ELs (NASEM, 2018). This study is limited by small sample size and limits inherent to interview data.

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