

Exploring the Interplay Between Preservice Teachers' Mathematical Beliefs and EB Students' Mathematics Education

Luis M. Fernández
University of Texas Rio Grande Valley

Ursula Nguyen
University of Nebraska–Lincoln

We explored the intersections between two sets of pre-service teachers' beliefs, revealing potential relationships between beliefs about mathematics and beliefs about EB mathematics education. PSTs whose beliefs about mathematics were consistent with reform-oriented mathematics were identified as social constructivists, and they were more likely to express equitable beliefs about EB mathematics education. However, we find a more mixed pattern regarding beliefs about EB mathematics education among PSTs identified as moderately-traditionalists. Specifically, we find that the association between PSTs' demographic backgrounds and engagement with EB issues and their endorsement of more moderate beliefs may differ across different groups of PSTs. This research contributes to understanding the complex interplay of teacher beliefs in mathematics and EB education, offering insights that can inform more effective teacher-preparation programs to enhance PSTs' ability to teach EB students effectively.

Keywords: Emergent Bilinguals, Pre-Service Teachers, Beliefs about Mathematics

While teacher-preparation programs have made strides in adopting asset-oriented perspectives regarding what Emergent Bilinguals (EB) students can achieve, research reveals that many pre-service teachers (PSTs) still graduate underprepared to meet the mathematical needs of EB students, including prevalent deficit-oriented views about how EB students learn mathematics (e.g., Fernandes, 2007; National Center for Education Statistics, 2013; Pappamihiel et al., 2017). These beliefs strongly influence the instructional practices that PSTs enact in their mathematics classrooms (Akinsola, 2008; Beswick, 2005; De Araujo, 2017; Wilkins, 2008).

Recent research has started exploring the experiences shaping PSTs' beliefs about EB students' mathematics education, including PSTs' beliefs about mathematics, its teaching, and learning and how these appear to influence their views on how EB students should learn mathematics (e.g., De Araujo, 2017; Janzen, 2008; McLeman & Fernandes, 2012). For that reason, identifying relationships between PSTs' beliefs about mathematics and EB students can further inform the development of more effective teacher-preparation programs. By addressing PSTs' preconceived notions about mathematics learning and teaching, these programs can enhance PSTs' capabilities to teach EB students. The study aims to answer two research questions:

1. What beliefs do PSTs seem to hold about the nature of mathematics, its teaching and learning, and the mathematics education of EB students?
2. Are there any relationships between PSTs' beliefs about the nature of mathematics, its teaching and learning, and the mathematics education of EB students?

The study utilizes a quantitative approach to collect data and situates its work within the broader context of research on teacher beliefs, encompassing beliefs about mathematics and the education of EB students. The hypothesis is that PSTs who share beliefs about mathematics that are aligned with reform-oriented efforts of mathematics teaching and learning will also share equity-oriented beliefs towards EB learners and mathematics.

Literature Review and Theoretical Background

Teacher Beliefs about the Nature, Teaching, and Learning of Mathematics

According to Borg's theoretical framework (1997, 2003, 2005) on teacher cognition, teachers enter teaching with existing mathematics beliefs, knowledge, and attitudes categorized as either instrumentalist, Platonist, or problem-solving orientations (Ernest, 1991; Raymond, 1997). These orientations represent distinct views of mathematics: instrumentalists see it as facts and rules, Platonists as static interconnected knowledge, and problem-solvers as dynamic and inquiry-oriented. This has spurred extensive research into exploring such teachers' beliefs about mathematics through various survey instruments, including the Mathematics Belief Instrument (Hart, 2002), the Mathematics Beliefs Questionnaire (Adnan & Zakaria, 2010), and the Teachers Beliefs Survey (Beswick, 2005; Hughes, 2016). These studies consistently reveal a divide between teachers who view mathematics as interconnected knowledge best acquired through student-guided experiences and inquiry-based learning and those who see mathematics as a finite set of facts and procedures conveyed directly to students, with limited room for exploration.

More recently, Hughes (2016) adapted Ernest's framework, categorizing instrumentalist and problem-solving/Platonist beliefs as traditional and constructivist beliefs, respectively. Research finds that teachers tend to align with either traditional or constructivist beliefs (Hughes, 2016; Paolucci, 2015). However, recently among newer teachers, another group has emerged whose mixed beliefs combine elements of both traditions. However, the literature on teacher beliefs rarely delves into the factors influencing these beliefs about mathematics' nature, teaching, and learning. Limited studies suggest a positive link between teachers' mathematical backgrounds (including coursework and teaching knowledge) and constructivist beliefs about mathematics (Ogan-Bekiroglu & Akkoç, 2009; Kutaka et al., 2018). Yet, the evidence in this area is inconclusive regarding the role of other factors, such as experiences with linguistically or culturally diverse students, on teachers' beliefs about mathematics.

Teacher Beliefs about the Mathematics Education of EB Students

In recent decades, studies exploring teachers' broad beliefs regarding EB students, extending beyond mathematics education, have surged. This body of literature finds that teachers often exhibit deficit views, perceiving their role mainly as content instructors (e.g., Tan, 2011; Garmon, 2005; Mellom et al., 2018). De Araujo (2017) observed that secondary mathematics teachers often chose procedure-focused tasks for EB students, reflecting their deficit-oriented beliefs about EB students' ability to engage with mathematics. Additionally, McLeman and Fernandes (2012) noted that even PSTs with overall positive beliefs about EB students also endorsed the commonly held belief that lack of parental and family involvement, potentially contributed to EB students' mathematics underachievement.

An intriguing aspect of this research is the exploration of factors shaping teachers' beliefs about EB students' mathematics education. Training in EB instruction appears to lead to more positive beliefs about teaching EB students (Pettit, 2011b; Polat & Mahalingappa, 2013). Similarly, PSTs who engaged in multicultural courses during their teacher preparation, specifically addressing EB student issues, tended to hold more positive beliefs about EB students and their mathematics performance. These PSTs also had opportunities to interact with EB students during their student-teaching experiences (McLeman, Fernandes, & McNuttly, 2012; McLeman & Fernandes, 2012).

Methods

This study aims to investigate a diverse array of PSTs beliefs, encompassing perceptions, attitudes, conceptions, and beyond. Therefore, the study adopts Borg's (2003) comprehensive conceptualization of teacher cognitions as its main theoretical framework, integrating various facets of teacher beliefs, particularly those related to the nature of mathematics and the mathematics education of EB students. This framework aligns with the study's perspective of teachers as active agents who base their instructional decisions on their situated understanding and therefore, frames PSTs' beliefs as a flexible yet robust collection of "what teachers know, believe, and think" (Borg, 2003, p. 81), particularly in the context of mathematics and the education of EB students.

We collected survey data from 84 PSTs attending a southwestern US public research university. Specifically, we recruited PSTs enrolled in an elementary teacher preparation program and pursuing either an ESL Generalist Certification ($n = 68$) or a Bilingual Generalist Certification ($n = 16$). As our intent in this study is to focus on views held by PSTs about the mathematics education of EB students as well as their beliefs about the nature of mathematics, we selected Bilingual and ESL elementary PSTs who had either completed ($n = 53$) or were currently enrolled ($n = 31$) in the mathematics pedagogy course (i.e., Mathematics Methods) for the elementary teacher preparation program. Through this course, PSTs were exposed to research-based instructional strategies for teaching mathematics in elementary grades.

To capture beliefs held by PSTs regarding the nature of mathematics, teaching mathematics, learning mathematics, and the mathematics education of EB students, we utilized two different sets of survey items. The first set, or Survey A, (Cronbach's $\alpha=0.77$) describes beliefs about mathematics and mathematics education and was comprised of 28 previously validated items (Hart, 2002). A sample item includes "A demonstration of good reasoning should be regarded even more than students' ability to find correct answers." Response categories were 5-point Likert-scales, ranging from 1=*Strongly Disagree* to 5=*Strongly Agree*, with higher scores indicating more alignment with reform-oriented efforts. The second set, or Survey B, consisted of 30 previously validated items (Cronbach's $\alpha=0.87$) describing beliefs about the mathematics education of EB students. One item from this set is "The inclusion of EB students in classes of mathematics creates a positive educational atmosphere." Response categories followed the same 5-point Likert scale described earlier, with higher scores indicating more asset-oriented views towards the mathematics education of EB students. Survey data collected also included PSTs' demographic background information, including gender, race/ethnicity, and previous college course experience.

As this study seeks to explore the potential relationship between PSTs' beliefs about mathematics and the mathematics education of EB students, we utilized cluster analyses, which is a descriptive statistical method appropriate for this exploratory study about PSTs' beliefs (e.g., Beswick, 2005; Rodriguez-Muñiz et al., 2022). For each set of beliefs (Surveys A & B), we utilized hierarchical cluster analysis to identify and categorize latent types of common beliefs shared by PSTs. To analyze the intersection between beliefs about mathematics (Survey A) and mathematics education of EB students (Survey B), we used a cross-tabulation analysis and identified unique relationships between these two sets of beliefs.

Results

Teacher Beliefs about the Nature, Teaching, and Learning of Mathematics, and the Mathematics Education of EB Students

Results from the hierarchical cluster analysis on Survey A responses provided a solution of three clusters (i.e., CA1, CA2, & CA3). On the other hand, results from the hierarchical cluster analysis on the responses of Survey B yielded two clusters that reflected the PSTs' beliefs pertaining as it relates to EB students' mathematics education (i.e., CB1 & CB2). These results were further validated by splitting the data into two equal sets and confirming the persistence of the same solution for the split data, respectively (Garson, 2012; Hair & Black, 2000; Sarstedt & Mooi, 2014). Furthermore, given that significant differences are to be expected among clusters (Hair & Black, 2000), a comparison of means for all survey items incorporated ANOVA and post-hoc tests among CA1, CA2, CA3 and CB1, CB2. Survey items that presented significant differences (i.e., $p < 0.05$) among all the two groups of clusters were used to create cluster descriptions and labels.

Focusing on Survey A clusters, Traditionalist PSTs (CA1; $n=29$) shared more traditionalist orientations towards mathematics. This includes beliefs that mathematics is a collection of isolated strands of knowledge best taught through repetition and reinforcement. Moderately-Traditionalist PSTs (CA2; $n=34$) shared similar beliefs about mathematics, such as the view that there exists a right or wrong answer in math, strongly contradicting the beliefs expressed in mathematics reform efforts. However, these and other similar traditionalist beliefs are not as strongly believed as those from CA1, and therefore the "Moderately" in the label. Social Constructivist PSTs (CA3; $n=21$), on the other hand, shared beliefs about mathematics, including its teaching and its learning, that strongly aligned with those of reform-oriented efforts. This includes beliefs about mathematics being best taught through a student-centered approach that values peer discussions, guided explorations, and self-discovery.

Regarding the beliefs about the mathematics education of EBs, or Survey B, Moderately-Equitable PSTs (CB1; $n=56$) expressed beliefs that align well with recommendations found in the literature on the learning and instruction of mathematics to EBs. However, beliefs in CB1 are "weaker" than those believed in CB2 ($n=28$). That is, PSTs in CB1 were more moderate compared to CB2 PSTs in how much they agreed and disagreed with research-based recommendations for EBs' mathematics education, and therefore the "Moderately" in the label for CB1 and "Equitable PSTs" for CB2, respectively. Demographic and other background information were also considered when exploring the composition of each cluster. However, results from the Chi-square and ANOVA tests did not reveal any significant associations.

Relationships between PSTs' Beliefs about the Nature of Mathematics, its Teaching and Learning, and The Mathematics Education of EB Students

The percentages from the crosstabulation analysis between the two sets of clusters of PSTs are shown in Table 1. We focus on the interesting yet important intersections formed by Moderately-Traditionalists and Moderately-Equitable (i.e., $CA2 \times CB1$) and Moderately-Traditionalists and Equitable (i.e., $CA2 \times CB2$) while recognizing that we also observed other relationships, such as between PSTs labeled as Social Constructivists and Equitable (i.e., $CA3 \times CB2$).

Table 1. Crosstabulation Between MBI Clusters and MEELBI Clusters

	Moderately-Equitable (CB1)	Equitable (CB2)
Traditionalists (CA1)	28 (49.6%)	1 (4.3%)
Moderately-Traditionalists (CA2)	23 (40.6%)	11 (40.2%)
Social Constructivists (CA3)	5 (9.8%)	16 (55.5%)
Total	56 (100%)	28 (100%)

Specifically, as seen in Table 1, both CB1 and CB2 shared a large proportion of PSTs that were labeled as Moderately-Traditionalists. This finding suggests the possibility that Moderately-Traditionalists' beliefs might be more susceptible to other factors, and these factors may contribute to these beliefs differently according to PSTs' beliefs about the mathematics education of EB students. In fact, looking closely at each proportion's composition revealed differences between Moderately-Traditionalists and Moderately-Equitable PSTs and Moderately-Traditionalists and Equitable PSTs, respectively. For example, PSTs within the Moderately-Traditionalists and Moderately-Equitable intersection were most likely to identify as White (72.7%) and be pursuing a Generalist/ESL certification (100%) whereas PSTs from Moderately-Traditionalists and Equitable intersection share more diversity in both ethnicity and degree plan. PSTs from the Moderately-Traditionalists and Equitable intersection were also more likely to be bilingual (52.6%) than those in the Moderately-Traditionalists and Moderately-Equitable intersection (37.35%). In terms of previous course enrollment, Moderately-Traditionalists and Moderately-Equitable PSTs reported the lowest average number of courses that focused on EB issues ($M=2.55$; $SD=2.16$) and the highest rate of interaction with EB students during their teacher education program ($M=2.57$; $SD=.731$). Moderately-Traditionalists and Equitable PSTs, on the other hand, reported a higher average number of EB-focused courses taken ($M=5.75$, $SD=3.36$) and the lowest rate of interaction with EB students during their teacher education program ($M=1.42$; $SD=.729$).

Discussion

As hypothesized, evidence suggests that PSTs who embrace progressive, reform-oriented approaches to mathematics education appear to be more inclined to endorse empirically-based strategies for effectively teaching EB students in mathematics. Conversely, PSTs with more traditional beliefs about mathematics seem to exhibit a degree of caution or reluctance when it comes to fully embracing research-based recommendations for the education of EB students in mathematics. However, there also existed a group of PSTs that, while adhering to traditional views on mathematics, paradoxically champion equitable practices when it comes to teaching mathematics to EB students. Several additional factors may also come into play, potentially shaping and influencing the beliefs of PSTs. Elements such as the ethnic and cultural backgrounds of PSTs, the extent of their exposure to EB-focused coursework during their educational journey, and the depth of their interactions with EB students during their student-teaching placements are all critical factors that warrant exploration. These variables suggest that the development of beliefs about mathematics education and equity for EB students is a nuanced process influenced by a multitude of contextual and experiential factors. Further exploring this holds the potential to better inform teacher preparation programs.

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