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Session Title Serving Multilingual Students in the STEM Content Areas

Session Type Paper

Presentation Date 4/16/2024

Presentation Location Chicago, IL

Descriptors English Learner, Mathematics Education, Teacher Education - In-Service/Professional Development

Methodology Mixed Method

Unit Division K - Teaching and Teacher Education

DOI 10.302/2007248

Teacher Growth in Mathematical Quality of Instruction for Emergent Bilinguals through Collaborative Professional Development

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Abstract

Many teachers reduce the language and cognitive demand of mathematical tasks to support Emergent Bilinguals (EBs), inadvertently withholding the opportunity to engage with rich mathematical tasks. This study employed collaborative professional development to work with an ELL-only Algebra 1 teacher to co-develop, co-teach, and co-analyze lessons designed to engage EBs in meaningful mathematical discourse. The research team used the Mathematical Quality of Instruction and Quality of Linguistically Diverse Teaching (QLDT) to measure improvement from pre-intervention to post-intervention lessons. Results indicate an improvement in teaching quality in almost every category, with some of the most notable changes occurring in the QLDT, suggesting that the teacher became more aware of EBs' needs and supported EBs to overcome their language barrier.

Purposes of the Study

The purpose of this research project is to measure a high school teacher's growth in mathematical quality of instruction (MQI) when working with Emergent Bilinguals (EBs) in Algebra 1, who are identified as English learners by their school district. We aim to investigate how a math teacher engages EBs in a meaningful mathematical discussion using rigorous mathematical tasks and how she incorporates tools for EBs in math classrooms through collaboration with a researcher. The research question is "How does collaborative professional development (situ-PD) impact a high school math teacher's instruction for EBs?"

Backgrounds and Framework

It is a common misconception that EBs are incapable of engaging with word problems and language-heavy mathematical activities (Reeves, 2006). However, it is essential to provide EBs with opportunities to socialize and connect with their daily lives to access mathematical tasks (Anhalt, 2014; Chval & Chavez, 2011). In fact, there are two overarching research-supported recommendations regarding teaching EBs: (1) Have and show high expectations of EBs, and (2) provide EBs with rich, various, and authentic contextual supports such as visuals, real-life examples, hands-on, and physical movements (Garrison & Mora, 2005; McLaughlin & Talbert, 2001; Pearn, 2007).

According to Moschkovich (2012), there are general guidelines for high-quality teaching that should be followed for EBs, such as using cognitively demanding mathematical tasks regardless of the EBs' English proficiency (Celedon-Pattichis & Ramirez, 2012). Moreover, there are various research-supported ways to communicate mathematics to EBs that go beyond the use of language, such as physical activities (Moses & Cobb, 2001), gestures (Fernandes, 2012a; Roth, 2001), visuals (I & Stanford, 2018), manipulatives (Boakes, 2009; Pearn, 2007), and or integrating students' culture (Furner, 2009).

Situated Professional Development

In this study, we employed situated professional development (situ-PD) (Jung & Brady, 2016), where a researcher and a teacher collaborated to implement the research-based strategies for EBs listed above. In this situ-PD model, a teacher and a researcher co-developed and co-taught mathematics lessons that embedded EBs' real-world contexts and co-analyzed students' data to improve the teacher's capacity to understand students' work. Traditional PD models, such as a one-time workshop with a large group of teachers, have little impact on teaching practices (Garet et al., 2010), making the collaborative approach of this situ-PD appropriate. Situ-PD invites teachers to stay in their classrooms to build new ideas about teaching mathematics, and their interpretation of students' work becomes the basis for the continuous development of their teaching.

Mathematical Quality of Instruction

To capture changes in teaching quality, we used the Mathematical Quality of Instruction Observational Protocol (MQI; Hill et al., 2008) as our analytical framework, along with the Quality of Linguistically Diverse Teaching (QLDT), developed by Sorto et al. (2018). The addition of QLDT is necessary to examine the teacher's instructional approaches for teaching mathematics to EBs. The MQI protocol includes components that measure the relationship and interactions among the teacher, students, and content (Hill et al., 2011; Learning Mathematics for Teaching Project, 2011). Domains include "richness of mathematics,", "working with students in mathematics,", "errors and imprecision," and "common core aligned student practices." The QLDT protocol extends the MQI protocol beyond general mathematics teaching to "teaching mathematics to linguistically diverse learners" (Sorto et al., 2018, p. 230). Some additional components included by Sorto et al. (2018) are the use of visual aids or supports, discussion of students' mathematical writing, and connections of mathematics with language.

Methods

Participants and Context

This study has been reviewed and approved by an institutional review board (IRB). The data were gathered in a large urban school district with a 21.92% EB population. This district operates a program where EBs can learn fundamental English and mathematics skills before being placed in regular schools because many recent immigrants have no previous formal schooling. Each high school in this district offers at least one ELL-only Algebra 1 course due to the high EB population, and all Algebra 1 courses use Illustrative Mathematics as their primary curriculum. This study is based on our collaboration with an ELL Algebra 1 teacher who is a first-generation immigrant from Latin America and fluent in Spanish and English. The students in the co-taught class include Spanish speakers from various Latin American countries, a Vietnamese speaker from an Asian country, and Kunama, Swahili, and French speakers from African countries. Their grades and level of English fluency vary. We collaborated with the teacher to design and present seven co-planned and co-taught lessons over one academic year.

Data Collection and Analysis

Both quantitative and qualitative approaches were used in the data analysis process. We first observed the teacher-only-driven classes from the beginning (pre-intervention) and the end (post-intervention) of the year to measure how the teacher changed her instruction through the situ-PD. Following the guideline of MQI, the two lesson videos were divided into 7.5-minute segments. Each segment was rated by two coders who completed online MQI training. One rater (first presenter) was present in coding all segments as an anchor. The four-scale rates were quantified as follows: not present = 0; low = 1; mid = 2; and high = 3. Including the six codes from the QLDT, we scored 27 codes and did not include the whole lesson codes because they have different scales in a more general manner than the segment codes. After individual coding, two raters met and talked to reach a sufficient level of consensus on their evaluations. If the two raters continued to score differently, we used the mean of the two scores. We calculated Cohen's kappa to measure the rater agreement (interrater reliability) and ran descriptive statistics (mean and highest scores) to assess the overall change in scores from pre- to post-intervention lessons. We first observed the average of all six segments from each of the pre- and post-intervention lesson videos to detect any shift or change. We also looked for the highest scores among the six video segments in the pre- and post-intervention lesson videos and compared them. Based on this quantitative analysis result, we identified the instructional approaches that changed most and found the pertinent discourses reflecting these changes from the transcripts. Then, we further analyzed the selected transcript excerpts based on the MQI criteria.

Findings

By comparing the results of pre- and post-intervention teaching practices, we found that the teacher's instruction quality improved in most of the codes. The averages of pre- and post-scores in all codes except two codes, "Remediation of Student Errors and Difficulties" (from 1.33 to 1) and "Students Work with Contextualized Problems" (from 1.67 to 1.5), stayed at the same level or changed positively. The teacher showed reduced "Remediation of Student Errors and Difficulties" because there were fewer incidents of students' misunderstanding and mistakes in the post-intervention lesson. Similarly, we interpret there were fewer instructional moments for "Students Work with Contextualized Problems" in the post-intervention lesson because the lesson spent a relatively long time on complex mathematical procedures, such as factoring and solving a quadratic equation, although it was to solve a real-life word problem. Both pre- and post-intervention lessons were based on contextualized problems, but the post-intervention lesson used a more rigorous task (solving a real-life word problem using a quadratic equation) than the pre-intervention lesson (determining variables). Among the increasing codes, "Record of Written Essential Ideas, Concepts, Representations, and/or Words on the Board" (from 1.17 to 2.33) and "Teacher Uses Student Mathematical Contribution" (from 1.17 to 2.33) showed the largest change.

In addition to the average, we observed the highest score within the same code in both pre- and post-intervention lessons and compared them. Like the result of the average comparison, most codes had an increasing pattern. Only one code, "Explanations (from 3 to 2)," decreased. The code that showed the largest shift is "Linking Between Representations (from 0 to 3)." Table 1 displays the three codes of the largest shifts in each average and the highest score.

Based on the quantitative analysis results, we analyzed the classroom discourse qualitatively, focusing on the codes of the largest changes: "Teacher Uses Student Mathematical Contribution" and "Linking Between Representations." As for how the teacher used students' contributions for the math instruction, we found the teacher mostly used the Initiate-Response-Evaluate approach in the pre-intervention lesson. The teacher-student interactions did not continue long enough to have a decent discussion because the teacher quickly gave the answer. In the post-intervention lesson, the teacher provided more exploratory questions to provoke students' ideas and linked students' answers to continue a mathematical discussion like the dialogue below.

Teacher: Where do you think you are going to start?
Student 1: Write the solution?
Teacher: Write the solutions. Okay, but we don't have the solutions yet. Where do you guys start?
Student 2: The factor?
Teacher: The factor? Not yet. Maybe that is going to be in the middle. What else?
Student 3: We had to apply the zero-product property?
Teacher: Yeah, but that is when you already have the factors. But that is a good idea. What else? Yes, the question is how you are going to start, where you are going to start with our problem.
Student 4: Apply the distributive property?
Teacher: Apply the distributive property. Okay, that is going to be good, but I already have to have the factors or the variables. If not, how I'm going to apply? So something else.
Student 5: Sketch the problem?
Teacher: Sketch the problem. So everybody has to sketch the problem, label that, and then you are going to share that piece.

In this excerpt, the teacher responded to each student's idea without saying it was incorrect. She encouraged students to keep finding various entry points by guiding them on how each idea could be used. At the end of the excerpt, the teacher accepted a student's idea of sketching the problem and expanded it as the next instructional step.

Regarding linking mathematical representations, the teacher had no attempt to link representations in the pre-intervention lesson. The teacher did not use visual representations but used only oral explanations, written text, or numerical examples on the board. In the post-intervention, linking mathematical representations was an intended instruction. For example, after the teacher guided students to understand the problem context and make their sketch, she drew a rectangle on the board and labeled each side length with expressions using variables. The teacher also asked students to link the shape and expression of each side length.

Discussion

Through the collaboration with the researcher, the teacher had an opportunity to learn and observe what EB-friendly teaching strategies look like, how to effectively interact with EBs, and how to make mathematical tasks more accessible to EBs. The reflection and co-analysis sessions helped the teacher look back and analyze her teaching. Our result showed that the situ-PD model that implemented research-based EB strategies effectively helped the math teacher in changing her instructional approaches to be more accessible for EBs. We observed that the teacher provided EBs with more opportunities to speak and participate in mathematics discussions by asking follow-up questions to guide students rather than give them direct answers to their questions.

Particularly, we found that more than half of the codes with the largest change were in the QLDT. This result implies that the teacher became more mindful of EBs' needs and provided EBs with various supports to overcome the language barrier. After the intervention, the teacher tried to incorporate students' thinking, avoid evaluating incorrect ideas, elicit students' thoughts more frequently, and utilize group work more effectively and frequently. Although both curricula for pre- and post-intervention lessons used contextual tasks, how the teacher made connections between representations, invited students' contributions, and made the tasks accessible to EBs were different.

We believe this project is significant because our findings provide important information for teachers about how to support EBs in learning mathematics, and the situ-PD helped the teacher improve her instructional design and approach more effectively for EBs. This project is aligned well with the conference theme in the way that this project challenges the prevalent misconception about the limited access EBs have when learning math.

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Table 1. The three codes of largest changes in the average and highest score from pre-intervention to post-intervention lessons.

Average	Change in Average	Highest score	Change in highest score
Teacher Uses Student Mathematical Contribution	1.17 (from 1.167 to 2.33)	Linking Between Representations	3 (from 0 to 3)
Record of Written Essential Ideas, Concepts, Representations, and/or Words on the Board	1.17 (from 1.167 to 2.33)	Use of Visual Aids or Support	2 (from 0 to 2)
Discussion of Students' Mathematical Writing	1 (from 0 to 1)	Discussion of Students' Mathematical Writing	2 (from 0 to 2)