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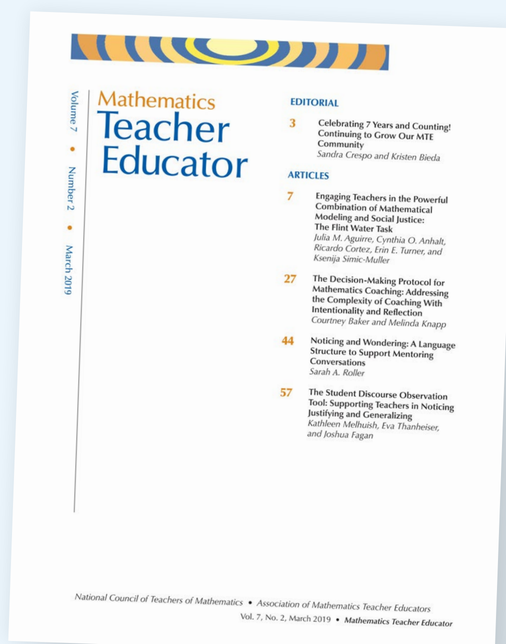
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NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

Empowering Mathematics Teachers to Support Emergent Bilinguals: A Collaborative Approach to Integrating Funds of Knowledge

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In this study, we explore a collaborative situated professional development program designed to support high school mathematics teachers in leveraging emergent bilingual (EB) students' funds of knowledge to enhance mathematical learning. As the EB population grows, teachers need professional development that integrates students' cultural and linguistic resources in rigorous, language-rich instruction. Through co-planning, co-teaching, and co-reflection, teachers and researchers collaborated to design instruction that connects academic rigor with students' lived experiences. Qualitative analysis revealed that teachers deepened their awareness of EBs' funds of knowledge and refined their instructional practices, underscoring the value of professional development that fosters more equitable and inclusive mathematics instruction.

Keywords: Funds of Knowledge; cognitive demand; emergent bilinguals; Collaborative Situated Professional Development; high school math teacher

With the growing population of culturally and linguistically diverse students in U.S. schools, there is a pressing need for teacher education that equips teachers with strategies to leverage students' cultural and linguistic resources, which are often overlooked in high cognitive demand mathematics instruction (Britsch, 2020). In this study, the term *emergent bilinguals* (EBs) refers to linguistically diverse students who are not yet fluent in the language of instruction—English, in the context of the United States. This term highlights their bilingualism as an asset for academic learning while also acknowledging their temporary need for academic support and accommodations to overcome language barriers. The term also conveys the expectation that they will soon become proficient bilinguals, emphasizing that they should not miss out on academic learning during their time of English acquisition. While teachers need to acknowledge the social and academic challenges EBs encounter in and out of school, EBs' knowledge and linguistic assets often remain underrecognized (Britsch, 2020). Additionally, many teachers are underprepared to effectively teach diverse learners (Aguirre et al., 2012).

Asset-based approaches emphasize the strengths and resources students bring to the classroom, rather than focusing on their deficits (Wilson-Lopez & Acosta-Feliz, 2022). One of the promising asset-based approaches is grounded in students' funds of knowledge (FoK) because it recognizes, values, and builds on the existing strengths and resources that students and their families bring to the learning process. It actively challenges deficit perspectives and seeks to create more equitable and effective learning environments by connecting classroom learning to students' lives outside of school ('t Gilde & Volman, 2021; Hunter, 2022). While these educational approaches are gaining prominence, there is a dearth of literature regarding how teachers apply FoK for EBs, specifically in mathematics education (Hunter et al., 2020).

To support teachers in leveraging EBs' FoK, we designed a collaborative situated professional development (CSPD) model that promotes teacher-researcher collaboration through iterative cycles of co-planning, co-teaching, and co-reflection. Using CSPD, we examine how high school mathematics teachers worked with a researcher to design and implement the 5-Act Task framework (I et al., 2020), an adaptation of Meyer's (2011) 3-Act Task. This framework integrates high cognitive demand tasks with culturally and linguistically supportive activities that draw on EBs' FoK. The study highlights how collaboration and reflective practice can advance culturally responsive and equitable mathematics instruction, guided by the question: "How do mathematics teachers grow in drawing on emergent bilingual students' funds of knowledge through participating in collaborative situated professional learning and implementing 5-Act Tasks?"

Theoretical Perspectives

This section establishes the theoretical framework used in this study for teaching EBs, highlighting the importance of leveraging FoK and maintaining cognitive demand in instruction.

Funds of Knowledge in Mathematics for Teaching Emergent Bilinguals

FoK refers to the culturally and historically accumulated knowledge and skills essential for individual and household functioning (Moll et al., 1992). This concept recognizes that all people and cultures possess valuable knowledge, extending beyond academic expertise to include skills from everyday experiences, like cooking and gardening, as well as cultural traditions (Johnson & Johnson, 2016; Williams et al., 2020). This notion has been expanded to encompass a broader range of contexts, including talents, interests, and observations beyond a school setting (Barton & Tan, 2009; Varelas & Pappas, 2006).

In this study, we recognize language as a cultural asset and a key element of FoK for EBs, where home languages, dialects, and ways of speaking serve as valuable learning resources (Wilson-Lopez & Acosta-Feliz, 2022). Teachers can integrate these linguistic practices for meaningful instruction (Razfar, 2012), extending Moll and González's (1994) concept of strategic language use in homes as FoK. These linguistic resources support academic, social, and intellectual growth. Furthermore, EBs develop crucial multimodal literacy skills through various communication forms (e.g., oral, text, images, gestures, symbols, digital tools) vital for everyday and academic success (Gillanders & Jiménez, 2004; Hammerberg, 2004).

Building on language as a key element of FoK, translanguaging dynamically integrates students' entire linguistic repertoires into instruction for communication, meaning making, and learning (García & Baetens Beardsmore, 2009; Reyes et al., 2016). In a translanguaging classroom, EBs use their full language system, helping teachers understand their mathematical reasoning (Gomez et al., 2020). Essentially, translanguaging offers a practical application of FoK in multilingual classrooms, supporting language development while valuing unique linguistic assets.

The concept of FoK challenges the assumption that underrepresented students, especially those from diverse populations whose culture and language are not dominant in their country, lack experiences and knowledge for academic success (Hunter, 2022). It instead highlights the strengths and educational capital all students bring to the classroom (Turner & Drake, 2016). When students see their knowledge reflected in the curriculum, it fosters engagement, motivation, improved academic outcomes (Civil, 1994), and a stronger sense of belonging (Hogg, 2011). Understanding FoK enables teachers to adapt strategies and content for diverse learners (Hogg, 2011), uncovering rich mathematical learning in homes and communities for more relevant experiences (Aguirre et al., 2012; Hunter et al., 2020). Using FoK allows students to make personal meaning of mathematics (Cribbs & Linder, 2013). Active participation from teachers, students, and families is crucial for deeply understanding the mathematics embedded in everyday activities (González et al., 2001). Table 1

Table 1

Mathematics-Related Funds of Knowledge Examples

Category	Source	Example of Mathematics-Related Funds of Knowledge
Workplace	Wilson-Lopez & Acosta-Feliz (2022)	Learning about ethical responsibility in engineering from observing workplace injuries in meatpacking plants.
Popular culture	't Gilde & Volman (2021)	Using computer games like *Minecraft* to create engaging mathematics activities, such as calculating surfaces.
Finance	Williams et al. (2020)	Discussing costs, discounts, and budgeting during shopping; applying proportional reasoning while cooking.
Agriculture	Hunter (2022)	Using measurement concepts to plan space for plantations, estimate hole sizes, and plan space between plants.
Health	Wilson-Lopez & Acosta-Feliz (2022)	Designing a shower chair for caregivers to accommodate a wider range of body types.
Travel	Aguirre et al. (2012)	Using regular travel experiences, like driving to a grocery store, to teach lessons on distance, time, and cost.
Sewing	González et al. (2001)	Applying symmetry and measurements in sewing, based on trade school education in Mexico.
Kitchen	Andrews & Yee (2006)	Counting cups and washing teaspoons while helping a family member prepare for large group visits.
Language	I et al. (2020)	Sharing words for *goat* and experiences with goats before solving a pattern problem related to goat fences.

synthesizes examples of FoK in mathematics learning from prior studies.

Research underscores teachers' crucial role in leveraging students' FoK to enhance mathematics learning, holding teachers accountable for understanding, valuing, and integrating diverse backgrounds and cultural practices. This includes learning about households (Cribbs & Linder, 2013), connecting mathematical knowledge bases (Aguirre & Bunch, 2012), creating relevant lessons (Gallivan, 2017), and positioning students as experts (Razfar, 2012). For EBs, fostering biliteracy is essential for expanding intellectual possibilities, accessing cultural resources, and affirming home experiences as vital to learning (Dworin, 2006). Effective professional development can aid teachers in connecting students' mathematical thinking with their cultural FoK.

Cognitive Demand in Math for Teaching Emergent Bilinguals

Effective teaching strategies for EBs support both language development and content learning by shifting to asset-based perspectives (Erath et al., 2021; I, 2019). Research emphasizes that regardless of English proficiency, EBs should engage in cognitively demanding mathematical tasks (Boston & Smith, 2009; Celedón-Pattichis & Ramirez, 2012; I, 2019; Moschkovich, 2010) that promote critical thinking, reasoning, conceptual connections, and problem solving (Stein et al., 2009). Low-level tasks limit deep understanding (Umansky, 2016); thus, teachers should maintain high cognitive demand with appropriate support (e.g., scaffolding, visuals, discussions) to foster problem solving, conceptual understanding, and language proficiency (Moschkovich, 2012). Given the interdependent relationship between language and mathematics (I & Son, 2019; Prediger & Wessel, 2013), maintaining cognitive demand allows teachers to effectively support both content and language development.

Asset-based instruction for EBs values linguistic and cultural resources, integrating linguistic support, cultural relevance, strategic visuals, and high cognitive demand (Aguirre et al., 2012; I & Martinez, 2020). Linguistic scaffolds are crucial for EBs to engage in mathematical discourse and develop language proficiency (Moschkovich, 2015) and can help to maintain the cognitive demand of tasks. Embedding students' cultural knowledge enhances engagement and connections (Civil, 2016). These strategies work together to enable EBs to deepen mathematical understanding, foster a positive learning attitude, and acquire English while valuing their native languages (Celedón-Pattichis & Ramirez, 2012; Sywulka, 2024).

Frameworks

This study utilized two frameworks—conceptual and pedagogical—to guide both research design and instructional structure. These frameworks provided a foundation for effectively integrating FoK and cognitively demanding mathematics tasks in teaching in ways that support EBs.

Conceptual Framework: Funds of Knowledge and Mathematical Cognitive Demand

We employed the Octant model (I, 2019) as our starting point, which originally featured three axes (cognitive demand, language demand, and context). To sharpen the focus on EBs' assets, in this study, we consolidate language and context into FoK, resulting in a two-dimensional framework that highlights the necessary intersection of FoK and high cognitive demand in mathematics, as shown in Figure 1.

The Task Analysis Guide (Boston & Smith, 2009; National Council of Teachers of Mathematics, 2014; Stein et al., 2009) describes high-level tasks as those that promote reasoning and problem solving (called *procedures with connections* or *doing mathematics*) and contrasts them with low-level tasks reliant on rote learning (called *memorization* or *procedures without connections*). Although overreliance on low-level tasks limits EBs' opportunities for mathematics learning, teachers can enhance cognitive demand by encouraging students to explain and justify ideas and make connections across multiple representations (Boston & Smith, 2009).

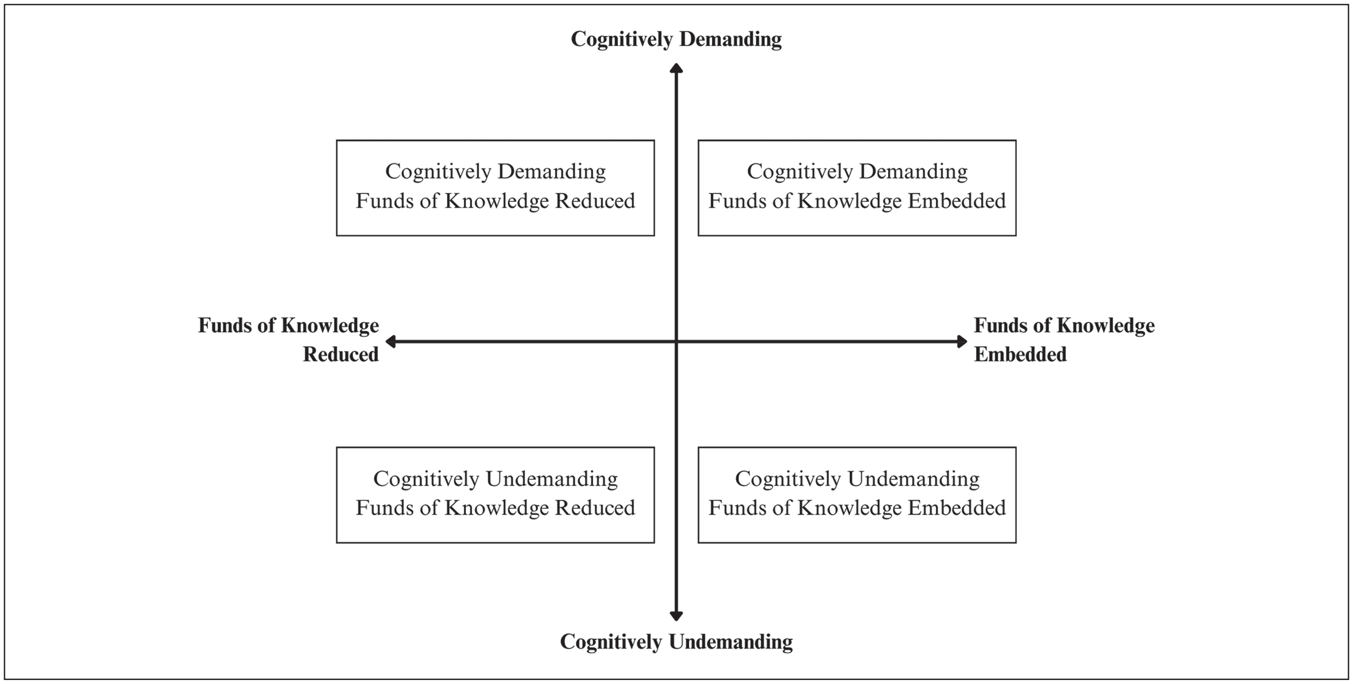
The Octant model emphasizes that FoK offers personally relevant contexts as entry points for high-demand tasks, and translanguaging acts as the linguistic bridge enabling EBs to articulate complex reasoning and thus maintain cognitive demand. Furthermore, contextual supports like visuals and real-world examples, often derived from FoK, maintain rigor while improving accessibility (I & Martinez, 2020). This framework provided the lens for analyzing teacher practice shifts (Hunter, 2022; I, 2019; Kim, 2024).

Pedagogical Framework: 5-Act Task

Our co-teaching lessons used the 5-Act Task framework (I et al., 2020), an adaptation that adds an Act 0 and an Act 4 to Meyer's (2011) original 3-Act Task. This structure was chosen because its acts are intentionally designed to maximize both FoK integration and cognitive rigor for EBs, with Acts 0 and 4 specifically designed for EBs. The embedded strategies in each act were repeatedly

Figure 1

Conceptual Framework of Funds of Knowledge and Mathematical Cognitive Demand



Note. Adapted from *The Task Analysis Guide* (Boston & Smith, 2009), used with permission.

addressed throughout the CSPD cycle, particularly during co-planning sessions.

Act 0: Invite Students to Share Funds of Knowledge

Effective mathematics instruction begins by assessing students' understanding of context, language, and prior mathematics knowledge before the main problem is introduced in Act 1. Act 0 fosters a safe space for sharing FoK and existing understanding. Some key strategies include making cultural connections (e.g., asking about similar home country games for a basketball problem) and using Notice and Wonder activities (Ray-Riek, 2013). These Act 0 activities help to establish context and assess and support understanding of the content of the problem presented in Act 1. The non-mathematical observations serve to deepen contextual and linguistic comprehension while fostering curiosity. In subsequent acts, teachers can then provide appropriate scaffolding based on what they have learned about students' experiences and thinking, ensuring all learners, especially EBs, can fully engage.

Act 1: Understand a Story With Conflicts Using Funds of Knowledge

In Act 1, students engage with relevant story problems via visuals, videos, or role-playing, often using a video to ignite curiosity. The open-ended tasks increase cognitive demand and promote problem solving. To support linguistic diversity and equitable access, a translanguaging activity asks student volunteers to read the problem in their home languages (García & Wei, 2014; Yi et al., 2024), recognizing these as valuable FoK. Students then formulate questions about the conflict of the problem. Collaborative strategies like Think-Pair-Share (Kaddoura, 2013) and collective note-taking foster interaction and deepen comprehension.

Act 2: Collect Information and Select Tools for Strategies

In Act 2, students actively identify and gather information needed to solve the problem. Structuring the task without all the information needed to find a complete solution increases the cognitive demand. Students must make reasonable assumptions based on context, drawing heavily on their FoK, determine what additional information is needed, and pose questions about the problem. This act emphasizes student agency, allowing them to select strategies, request information, and identify tools (Nieminen et al., 2022). Teachers provide targeted support, ensuring resource access while maintaining student ownership of the problem-solving process.

Act 3: Resolve Conflicts and Solve Problems

In Act 3, students construct mathematical models based on gathered information and assumptions. To foster independent exploration and productive struggle, students first develop and test their models without immediate

Figure 2

Sample 5-Act Task Lesson Overview

Math Objective: Students will be able to find solutions to quadratic equations via graphs or factored forms of equations.

Language Objective: Students will be able to use vocabulary about quadratic functions/equations in their math work.

Act 0	Students are shown a quadratic graph with three forms of equations on the board and asked to put matching magnetic word cards on different graph components: vertex, x-intercepts, y-intercepts, origin, standard form, factored form, and vertex form. Students are then shown different pictures (bridge, water fountain, etc.) and asked, "Where do you see a parabola?"
Act 1	The teacher facilitates a Notice and Wonder activity by showing a video and a picture of a basketball being shot toward a hoop.
Act 2	Students make assumptions and ask questions about necessary information to solve the problem.
Act 3	Students attempt to solve the problem for 3 minutes without the teacher's help. After 3 minutes, the teacher provides table and graph templates to the students to help them solve the problem without lowering the cognitive demand of the task by asking guiding questions, suggesting representations, or building on students' ideas.
Act 4	Students conduct a Gallery Walk, where they examine, comment on, and ask questions about their peers' work. Students may share their work in their home language with the class.

teacher intervention (Hofmann & Mercer, 2016). Teachers then provide targeted guidance—posing questions, prompting reasoning, and facilitating reflection—to maintain cognitive demand and ensure students refine their understanding.

Act 4: Share Collective Communication/Thinking Process

In Act 4, students collaboratively present solutions and reasoning, fostering dialogue and idea exchange. This sharing builds pride, strengthens agency, and boosts confidence in mathematical and linguistic abilities (Grant et al., 2015). To support diverse expression and leverage FoK (including home languages), students can use mathematics journals, engage in gallery walks, and present as a group in preferred languages. These approaches allow effective communication via writing, speaking, or visuals, maintaining the cognitive demand through deeper processing and articulation (Figure 2 provides a lesson summary for a sample 5-Act Task modified from Will It Hit the Hoop [Meyer, 2016]).

Methods

This comparative case study (Bartlett & Vavrus, 2017) examines cases of two teachers who demonstrated the most growth over the study in their mathematics instruction and support for EBs. These two cases also allow for comparison of how the teachers used cognitively demanding tasks and FoK to "trace across individuals, groups, sites, and time periods" (Bartlett & Vavrus, 2017, p. 8).

Context and Case Selection

This three-year study occurred in a large, linguistically diverse urban Midwest school district (with more than 20% EB students), involving seven teachers of EB students. In Years 1 and 2, teacher participants taught Algebra I, and in Year 3, teacher participants taught Pre-Algebra. To identify teachers for this comparative case study, we used the Mathematical Quality of Instruction instrument (Hill et al., 2012) to assess mathematics instructional quality and the Quality of Linguistically Diverse Teaching rubrics (Sorto et al., 2018) to assess EB support. Because they demonstrated the highest growth on both assessments, we selected Ms. Hunter and Mr. Ramirez (pseudonyms) as focal cases. Because neither rubric explicitly measures teachers' use of FoK, we focused on examining how CSPD and 5-Act Tasks can be employed together to help mathematics teachers of high-quality instruction leverage students' FoK to support access to cognitively demanding mathematics tasks.

Ms. Hunter, a white monolingual teacher with more than 25 years of teaching experience, taught two Algebra 1 classes for only EB students. Her 21 participating students spoke Spanish, Karen, Karenni, French, Swahili, Burmese, and Somali. Mr. Ramirez, a bilingual Latino mathematics teacher, taught one Pre-Algebra class for only EB students with interrupted education. With three years of experience, this was his first year teaching a mathematics class for only EB students. His 11 participating students spoke Spanish, French, Pashto, Arabic, and Dari/Persian.

Collaborative and Situated Professional Development

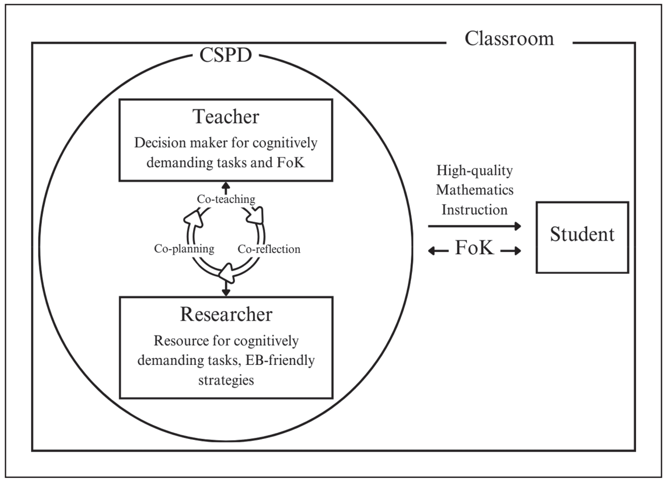
We designed the CSPD model by integrating collaborative and situated professional development (PD) approaches. Collaborative PD emphasizes social learning and knowledge co-construction via co-planning and co-teaching (Holmqvist & Lelinge, 2021). Situated PD, based on situated learning theory (Lave & Wenger, 1991), promotes effective learning through active participation in authentic classroom settings. Together, these approaches provided the PD context in which teachers engaged in meaningful collaboration and reflection. We designed CSPD by integrating the co-planning and co-teaching components of Collaborative PD with the authentic classroom context emphasized in Situated PD. Within this structure, we collected and analyzed data to examine how teachers' practices around cognitive demand and students' FoK evolved.

The CSPD cycle involved monthly co-planning, co-teaching, and co-reflection sessions (seven cycles) using the 5-Act Task framework. This process fostered shared expertise: The research team provided insights on EB strategies, and the teachers contributed knowledge of students' FoK (e.g., prior math knowledge, languages, lives, interests). During co-planning, the research team offered cognitively demanding mathematics tasks emphasizing features of being open-ended, having multiple entry points, and fostering student agency in various contexts. Teachers selected tasks considering students' FoK, co-developing all lessons under the research team's guidance, aiming to maintain the high cognitive demand of tasks and ensure that linguistic and contextual supports were accessible. For instance, Act 0 was facilitated openly, encouraging broad, FoK-driven observations and questions to elicit diverse perspectives in order to foster engagement in the problem presented in Act 1. Figure 3 illustrates this collaborative effort to deliver high-quality, FoK-grounded mathematics lessons.

Co-teaching occurred in authentic classrooms, adhering to district standards. Initially, the researcher modeled effective behaviors, responses, and questioning strategies that encouraged EBs to share ideas and FoK; they also provided scaffolding without diminishing cognitive demand, gradually transitioning leadership to the teacher. Following each teaching session, the research team and teacher reflected on how students leveraged home languages and/or FoK for problem solving and developed their own models, keeping EBs' assets central. Throughout the CSPD cycle, teachers were consistently encouraged to select high cognitive demand

Figure 3

Visual Representation of the Collaborative Situated Professional Development (CSPD) Model



Note. EB is emergent bilingual, and FoK is funds of knowledge.

mathematical tasks and actively draw on students' FoK, including cultural experiences and home languages.

Data Collection and Analysis

We collected and analyzed a comprehensive dataset for each teacher over three years, encompassing pre- and post-interviews conducted immediately before and after research activities, student artifacts, and video-recorded lessons (two to four solo; seven co-planning, co-teaching, and co-reflection cycles per teacher). Following Dedoose (2005), we coded transcribed data focused on teacher discourse, mathematical tasks, and strategies for cognitive demand and FoK. The second and third authors, well-acquainted with the dataset, independently open-coded separate portions. We concurrently developed sub-codes (e.g., FoK incorporation, cognitive demand adjustment). Our collaboratively refined coding manual (Table 2), built on shared understanding and consistent application, ensured coding efficiency and rigor (McCartan et al., 2023). Coders maintained regular communication for consistency and pattern identification, supporting a trustworthy and thorough analysis.

We examined patterns in the codes over time, both within and across each case. We compared the teachers' practices in the early and later stages of CSPD to identify meaningful growth and changes in each teacher's practices across the six codes listed in Table 2.

Findings

We analyzed how Mr. Ramirez and Ms. Hunter integrated cognitive demand and FoK to answer our research

Table 2

Example Code Description With Excerpts

Code	Description	Excerpts
		Cognitive Demand
Excessive scaffolding	Provides support in a way that limits students' ability to engage with math or productively struggle.	"No, you're going to take all the numbers, all the ages, all the numbers that we wrote up there, and then divide by 17. You're going to add 13, 14, 15, 15, all of them until the end. And then you divide by 17 because there's 17 of us in here."
Open-ended non-algorithmic thinking	Poses problems with multiple pathways or creative strategies.	"You can draw, you can graph, make assumptions. We're fine, as long as you can explain what assumptions you're making, you're ready to go for it."
Guiding questions	Asks questions to guide students to recognize the errors, get them back on track, or help them make progress toward their learning goals.	Teacher: By half. Because then we got from the big piece to a small piece. What happens if I do it again? Students: It gets smaller. Teacher: It got smaller again, by how much? Students: Two times. Divide by two. Teacher: Divide it by two, so the area gets smaller by—. Students: 0.25.
		Funds of Knowledge
Connection to life experiences	The teacher connects the math concept to students' life experiences.	Student: I hope Argentina wins [in the World Cup]. Teacher: Does it happen every year? Every time? Students: No. But most. Teacher: Yes. But which four years? What if I said between 2014 and 2018? Decreased when? Students: 2014. . . It decreases, then it goes down here and then up.
Problem with real-life context	The teacher poses a problem with a real-life context.	"It will take 8.5 minutes to get to school. . . . That is the average time it takes for us to get to school. Is it going to take eight-and-a-half minutes every single time?"
Students' use of home language	The teacher allows students to use their home language to work with others.	Students: *Para ella, los dos están corriendo a la misma velocidad* [To her, the two of them are running at the same speed]. Teacher: *Si corren a la misma velocidad, las líneas van a tener la misma* [If they run at the same speed, the lines will have the same].

question on teacher growth via professional learning and 5-Act Tasks. In general, we found that Mr. Ramirez prioritized linguistic FoK and Ms. Hunter focused on lived experiences and open-ended tasks. The strong code co-occurrence, especially among *open-ended non-algorithmic thinking*, *connection to life experiences*, and *problem with real-life context*, suggests that co-planning successfully emphasized FoK while maintaining cognitive demand. We illustrate their growth via two contrasting lessons per teacher.

Ms. Hunter's Case: From Heavy Scaffolding to Meaningful Context

Ms. Hunter's coding results (Table 3) show a notable shift in Ms. Hunter's teaching across nine lessons. Her pre-CSPD lesson had low cognitive demand (e.g., *excessive scaffolding* = 3, *open-ended thinking* = 0), but during and after CSPD, she integrated high cognitive demand and FoK practices. Her post-CSPD lesson showed sustained improvement (*excessive scaffolding* = 0, *open-ended thinking* = 7, *connection to life experiences* = 5, *problem with real-life context* = 2).

Without CSPD: Cognitively Undemanding and Funds of Knowledge Reduced

Before starting CSPD, we observed one of Ms. Hunter's typical lessons—on measures of central tendency and outlier effects—to establish a baseline. Students previously learned how to find the mean and median. The lesson focused on memorizing and applying procedures to calculate, lacked real-life contexts, and used excessive scaffolding that lowered cognitive demand. Figure 4

Figure 4

Dialogue Between Ms. Hunter and One Emergent Bilingual Student in the Pre-CSPD Lesson

Ms. Hunter:	What's the median there? Show me. Show me. Cross off. [Indicates with her finger that the student should cross off numbers on the ends of the dataset, as they have been taught in a previous lesson, to isolate the middle number(s).]
Student:	[Crosses off the numbers at the end.]
Ms. Hunter:	Okay, next one. Next one [points to the number that is to be crossed off].
Student:	[Crosses off additional numbers until only the number in the middle remains.]
Ms. Hunter:	There's only one number. There's not two, there's only one number. It is five, so that's fine [points to his answer to indicate it is correct]. But here, it's not going to be [indicates a different problem]. So, let's do the same thing. Cross off.

shows an excerpt where Ms. Hunter provides practice problems and a student struggles with the median.

In this conversation, Ms. Hunter directed students without assessing their understanding, using commanding discourse (e.g., "Show me," "Cross off") and physical gestures (lines 1 and 2). Lacking guiding questions for misconceptions, she repeated commands without paraphrasing (lines 1 and 5) and gave immediate instructions, allowing no time for the student to process information. The student silently complied (lines 4 and 6), but understanding remained unclear because of the extensive scaffolding, which led to the student following directions and providing minimal input. This exchange exhibited low cognitive demand and limited use of students' FoK, as the teacher elicited no student understanding.

With CSPD: Cognitively Demanding and Funds of Knowledge Embedded

The exponential growth lesson, using a "paying it forward" context, was strategically chosen for observation because it occurred late in Ms. Hunter's CSPD participation, occurred after she had received ample 5-Act Task guidance form the research team, and demonstrated positive shifts across all codes.

Following the lesson plan developed from the co-planning session, in Act 0, students shared ideas on the prompt: "Think about an idea to change our world; put it into action." Act 1 then introduced a video clip from the movie *Pay It Forward*, prompting discussion on real-life examples before presenting the main task: "How long would it take to help every person at our high school if good deeds are passed on to two, three, four, or five people?" To ensure comprehension, we displayed a translation slide with the problem in all student languages, and Ms. Hunter encouraged students to read it aloud in their native languages. Groups determined the number of people to help and choose their own strategies to solve the task. During the co-planning session, we discussed ways to incorporate the students' FoK into the story. Ms. Hunter emphasized encouraging students to define parameters and make assumptions for their models, even considering scenarios where rules might not be perfectly followed. This leveraged the video's story for contextual understanding and maintained the cognitive demand of the task by allowing multiple pathways. Ms. Hunter

Table 3

Average Code Frequencies per Lesson for Ms. Hunter Before, During, and After Collaborative Situated Professional Development (CSPD)

	Number of Instances of Code per Cycle					
	Cognitive Demand			Funds of Knowledge		
Phase	Excessive Scaffolding	Open-Ended Non-Algorithmic Thinking	Guiding Questions	Connection to Life Experiences	Problem With Real-Life Context	Students' Use of Home Language
Pre-CSPD	3	0	1	0	1	0
During CSPD	2	4.71	2.29	12.25	7.25	3.50
Post-CSPD	0	7	1	5	2	0

Figure 5

Dialogue Between Ms. Hunter and an Emergent Bilingual Student Group in the Sixth Co-Teaching Lesson

1	Ms. Hunter:	So do you think, from what he said, could it get to the whole world?
2	Student 1:	Yes.
3	Student 2:	He only started with one person.
4	Student 1:	One person, two persons, and then you take all the world.
5	Ms. Hunter:	Very good. You all are amazing. How about any wonders?
6	Student 3:	I wonder if it has to do with the initial value.
7	Ms. Hunter:	Good. Others? Have you heard of the word pay it forward before?
8	Students:	No [with some yeses].
9 10	Ms. Hunter:	There's a couple yeses. Does anyone have an example where you've seen it before? Because there's been things on TikTok.… Anything comes to mind?
11	Students:	Viral … something?
12 13 14	Ms. Hunter:	Yeah, [...] I have seen it before when they're like, you're in a Starbucks line and someone pays for like 10 cars, and they keep paying it forward and pay for someone else.
15	Students:	Oh, that.

enthusiastically fostered student agency, stating, "I'll actually find it interesting if anyone would pick in their minds, I don't know if they would do the not-perfect world in their model. So, if they do, it'd be very interesting to see how they do it." The excerpt (Figure 5) illustrates how Ms. Hunter built on student responses and lived experiences to facilitate mathematics task comprehension.

In this example, Ms. Hunter engaged a student group in a common CSPD activity (Notice and Wonder) about the video. Her initial question (line 1) built on student observations (lines 2–4), expanding the discussion globally. After acknowledging findings (line 5), she posed another open-ended question. Starting at line 7, Ms. Hunter checked understanding of "pay it forward" with relevant real-life examples. During co-planning, she ensured example relevance (e.g., suggesting Starbucks rather than the TikTok ice bucket challenge because the latter was outdated for her students). This illustrates Ms. Hunter's intentional use of students' FoK, connecting their lived realities to the mathematical context. By eliciting student ideas, she fostered an environment that values FoK for mathematical problem solving.

After she assessed that students understood the task, students actively sought necessary information during Act 2, such as school population. Then, in Act 3, students solved the task using various strategies. Figure 6 displays their group notes, encompassing observations, questions, mathematical work, and ideas in diverse forms including diagrams, graphs, equations, tables, and written explanations. In Act 4, students used the notes for group presentations; Ms. Hunter encouraged home language use ("You can do it in your language if you'd like"), leading two groups to present in their native languages.

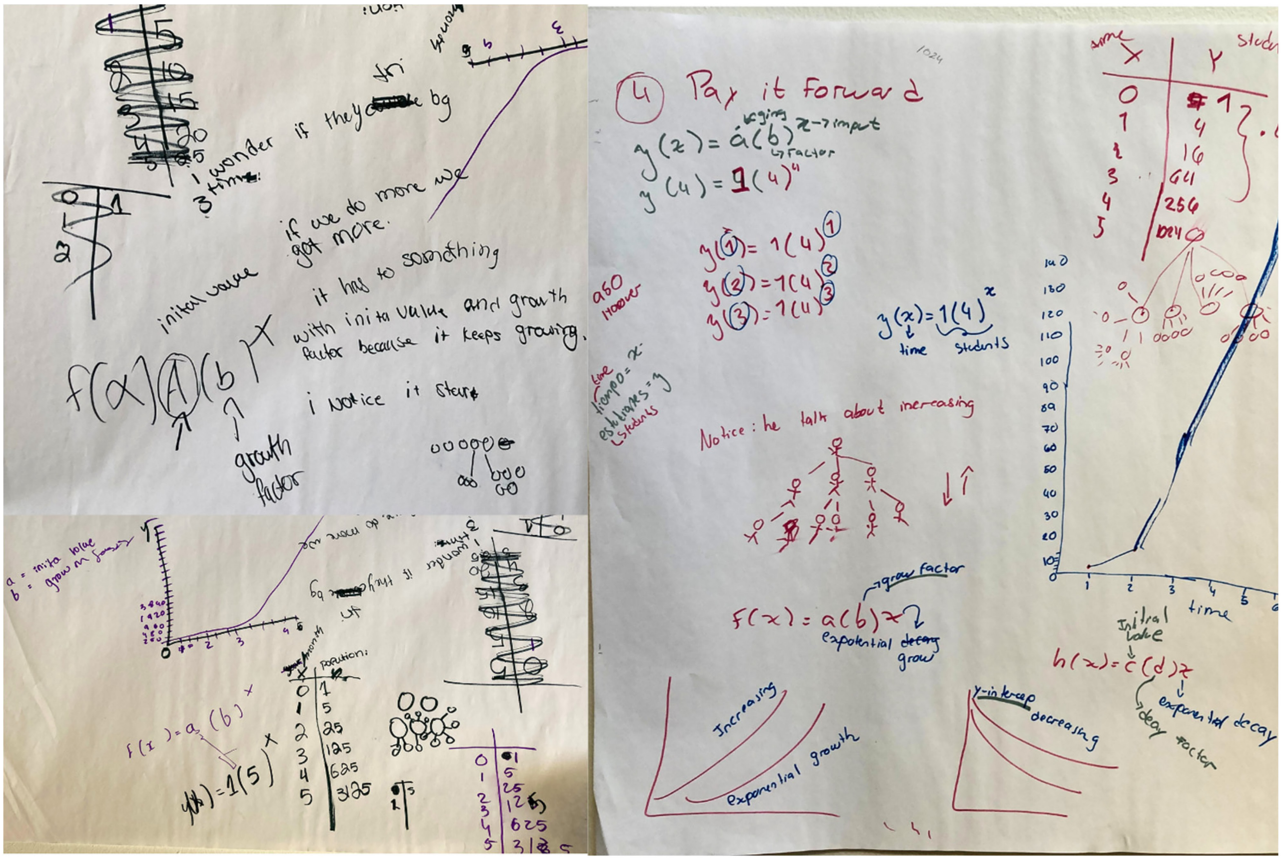
A visible shift occurred in Ms. Hunter's instruction later in the CSPD participation, contrasting with her pre-CSPD lesson's low cognitive demand tasks that relied on excessive scaffolding. This lesson demonstrated her design of cognitively demanding tasks through open-ended, non-algorithmic questions. She also recognized the importance of leveraging student's FoK, "I liked it was something like in their world . . . like how we can help the whole world, or just like one person, so I think it was nice open-ended to where they could take off." In her exit interview, Ms. Hunter further emphasized the importance of embedding meaningful context, reflecting on a successful lesson on the World Cup soccer championship. In this lesson, we first invited students to share what they knew about the World Cup and then asked students to analyze a graph of the number of goals scored over the past 30 years. Ms. Hunter described:

> **I really liked the soccer one because it was around the time of the World Cup, and it is something that most of the students really were passionate about. So, it was a good connection. I know it was hard to find the graph and the data to use, but it was good.**

Here, she intentionally tapped into students' FoK by aligning the lesson with their interests.

Figure 6

Student Groups' Collective Notes in Ms. Hunter's Lesson



Mr. Ramirez's Case: From Procedural Scaffolding to Students' Lived Experiences

Mr. Ramirez's coding results (Table 4) show a positive shift in the frequency of cognitive demand and FoK practices. In a pre-CSPD lesson, he relied heavily on over-scaffolding (*excessive scaffolding* = 5) and lacked high cognitive demand/FoK practices. During CSPD, over-scaffolding dropped, and FoK practices increased. Post-CSPD lessons showed sustained adoption of guiding questions and real-life connections (*guiding questions* = 2.5, *problem with real-life context* = 3), although over-scaffolding returned to pre-CSPD levels.

Without CSPD: Cognitively Undemanding and Funds of Knowledge Reduced

Before CSPD, we observed two lessons where Mr. Ramirez taught exponential expression evaluation. Students, familiar with exponents, primarily practiced

Table 4

Average Code Frequencies per Lesson for Mr. Ramirez Before, During, and After Collaborative Situated Professional Development (CSPD)

	Cognitive Demand			Funds of Knowledge		
Phase	Excessive Scaffolding	Open-Ended Non-Algorithmic Thinking	Guiding Questions	Connection to Life Experiences	Problem with Real-Life Context	Students' Use of Home Language
Pre-CSPD	5	0.5	0	0.5	0	8
During CSPD	1.14	2.86	2.43	3.71	1.14	8
Post-CSPD	5	0	2.5	0	3	7.5

Figure 7

Dialogue Between Mr. Ramirez and an Emergent Bilingual Student in the Pre-CSPD Lesson

1	Mr. Ramirez:	Yeah? How did you do it?
2	Student:	Three times five.
3	Mr. Ramirez:	That's not three times five. It's three to the fifth power. Remember how we did it on our calculator?
4	Student:	Yeah.
5	Mr. Ramirez:	Okay. Hit the clear button [on the calculator]. Hit the clear button. So, hit three.
6	Student:	Three.
7	Mr. Ramirez:	Caret [^] five.

procedural calculations with minimal conceptual exploration or real-life connections. For instance, the excerpt from the second pre-CSPD lesson (Figure 7) shows students evaluating equations as true/false, focusing on notation and distinguishing exponentials from multiplication.

In this exchange, Mr. Ramirez decreased cognitive demand by prioritizing procedural accuracy over conceptual understanding. He immediately corrected a student's misunderstanding (3×5 vs. 3^5) without prompting reflection (line 3). Subsequent interactions focused on calculator steps for 3^5, even after the student acknowledged remembering (line 4). These actions limited independent practice and lacked connections to the student's cultural or experiential knowledge, making the lesson feel disconnected.

With CSPD: Cognitively Demanding and Funds of Knowledge Embedded

In the fifth co-taught lesson, Mr. Ramirez engaged students in a real-world financial decision-making task comparing two job offers: a pizza shop ($100 hiring bonus, $10/hour) versus a grocery store ($50 hiring bonus, $25/hour). This lesson illustrates how his typical teaching practices developed during the CSPD phase, maintaining high scores in cognitive demand and FoK while minimizing excessive scaffolding. During co-planning, Mr. Ramirez explained his context selection rationale, citing its relevance to his own experience: "I literally did this exact thing where I compared how I was going to get paid between two schools and which one would be more worth my time."

Act 0 in the lesson began by revisiting the previous session's rabbit and turtle race graph. Mr. Ramirez used Think-Pair-Share, prompting students to find the graph's intersection point, emphasizing the meaning of the intersection point in a system of equations. He often used Spanish:

> ***Estamos buscando la solución del graph, ¿verdad? Te acuerdas cuando hicimos los graphs el otro día, que teníamos dos graphs cruzando, y donde cruzan es la solución. ¿Dónde está el solución del graph?*** **[We're looking for the graph solution, right? Do you remember when we did the graphs the other day, that we had two graphs crossing, and where they cross is the solution. Where is the solution of the graph?]**

Most students responded in Spanish, confirming that the solution is where two lines intersect.

Next, Mr. Ramirez introduced the main Act 1 task by projecting a slide comparing two familiar jobs: Hyvee and Little Caesar's Pizza. Students excitedly shared initial thoughts on work preference and pay, with some quickly commenting, "$10/hour isn't good, but $25 is." The subsequent slide posed the central question, "Which job pays you better?" translated into all students' languages, and Mr. Ramirez encouraged student volunteers to read it aloud in their home languages.

Students wrote their notices and wonders about this task on collective notes (Figure 6). Figure 8 presents a discussion with an EB on whether initial advantage of one of the job options would persist over time. Mr. Ramirez increased cognitive demand by promoting reasoning instead of providing the answer, a clear shift from his pre-CSPD lesson. He prompted a student (line 3) to predict long-term outcomes and used probing questions (lines 5, 7, 9, 11, 13, 15) to foster deeper mathematical thinking and justification. He also leveraged students' FoK by continuing the discussion in Spanish (line 15) when the student responded in their home language (line 14), supporting deeper understanding and articulation.

In Act 2, when students asked for the number of hours, Mr. Ramirez explained flexibility: "What if I told you the answer changes depending on how many hours you do?" By refusing an exact number, he avoided excessive

Figure 8

Dialogue Between Mr. Ramirez and One Emergent Bilingual in Act 1

1	Mr. Ramirez:	Anybody else got a notice? What did you get?
2	Student:	I noticed that the [inaudible]. Yeah, they do that first day only.
3	Mr. Ramirez:	It's only the first day, right? So what do you think happens after a certain number of days?
4	Student:	[Inaudible.]
5	Mr. Ramirez:	You're saying it's better for the first day, right?
6	Student:	Yeah.
7	Mr. Ramirez:	Is it always going to be better?
8	Student:	No.
9	Mr. Ramirez:	No. Why?
10	Student:	They're going to pay you 10.
11	Mr. Ramirez:	Well, they're only going to pay you 10, right? So what does that mean about the second job?
12	Student:	It's better.
13	Mr. Ramirez:	It's better. How is it better?
14	Student:	[Spanish, inaudible.]
15	Mr. Ramirez:	*¿Por qué? dime por qué?* [Why? Tell me why?]

scaffolding, guiding students to model the wage-hour relationship and maintaining the cognitive demand. In Act 3, students explored various representations and solution pathways (Figure 9). They initially stated their preferred store, then mathematically proved their choice by testing one or two hours before progressing to equations and graphs. In Act 4, students concluded by writing a journal entry addressing which job was better for different hours (see the image in the bottom right corner of Figure 9). This lesson exemplified meaningful learning by integrating both cognitive challenge and cultural relevance.

After the lesson, Mr. Ramirez reflected on the authenticity of the task, stating: "I thought they did [respond well to the story]. . . . I was surprised that they immediately knew the second job was better. . . . That's a good life skill. . . . It's just a little extra cash."

Contrasting his pre-CSPD lessons with excessive scaffolding and disconnection from real-world context, Mr. Ramirez's co-taught and post-CSPD lessons notably shifted toward guiding and open-ended questioning, incorporating real-life mathematics problems. In co-planning sessions, we repeatedly encouraged Mr. Ramirez to integrate students' FoK, withhold direct answers, and leverage home languages. He notably gravitated toward money as a context, using it in three of the seven co-planned lessons. In his exit interview, he confirmed this deliberate shift:

I think a lot of them understand how a lot of the mathematics that we did in that class was useful to the real world. Whenever we do stuff involving money, they get extra engaged because they understand, oh, this applies to what I want to do or what the real world is like.

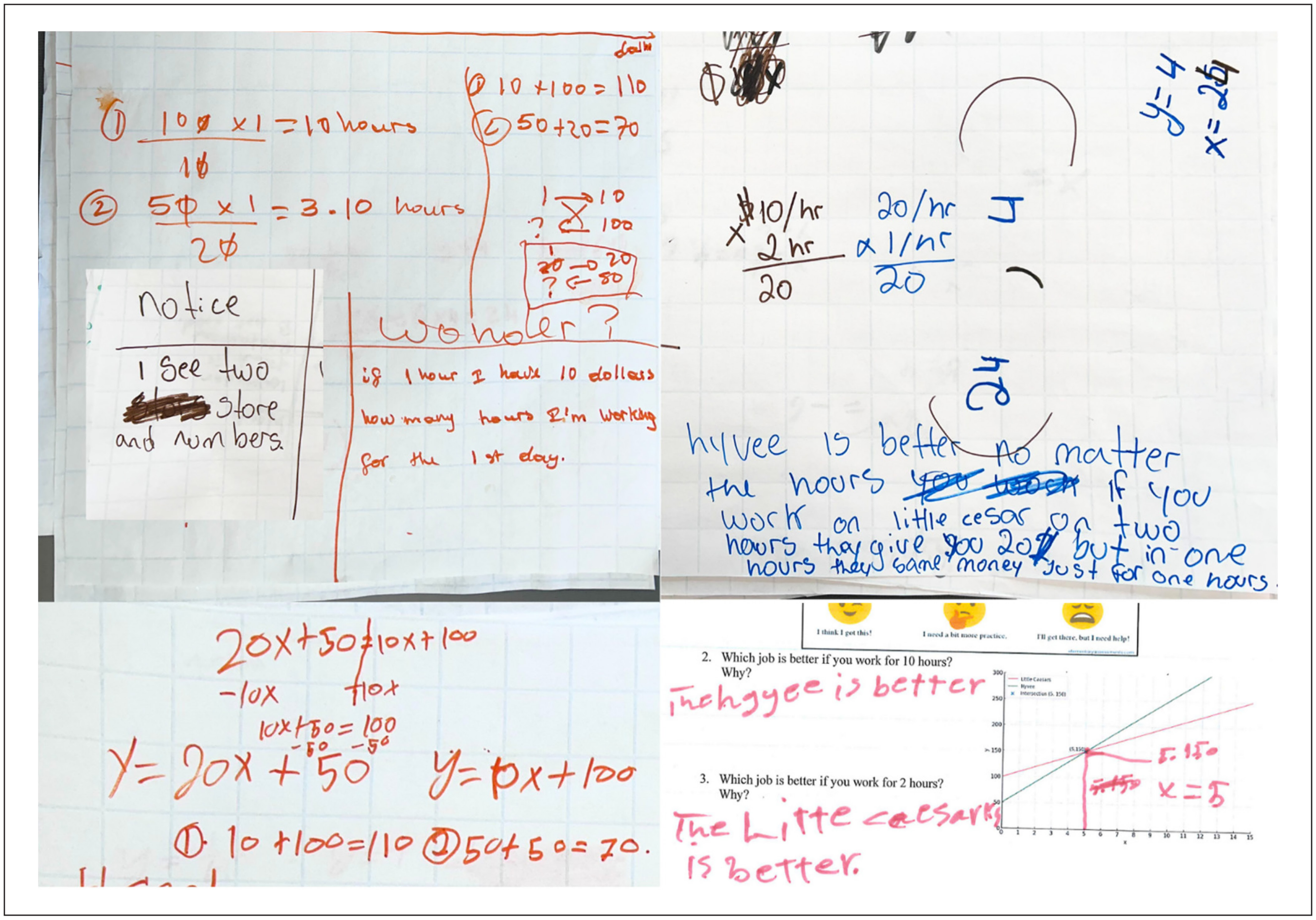
By prioritizing students' FoK, Mr. Ramirez increased engagement and fostered authentic opportunities for higher-level mathematical reasoning, moving his practice from delivering procedures to facilitating meaningful inquiry.

Discussion

Our findings illustrate that both monolingual and bilingual teachers can grow in leveraging students' cultural and linguistic resources while maintaining rigorous mathematical thinking (Moschkovich, 2013). However, this growth manifested distinctly based on their linguistic resources. Ms. Hunter, who is monolingual, learned to create demanding, open-ended tasks embedded in relevant contexts, a shift influenced by co-planning discussion when we discussed the relevance of the "pay it forward" idea and post-lesson reflections, especially on the soccer World Cup lesson. Mr. Ramirez, who is bilingual, continued to effectively use Spanish translation (e.g., seamlessly switching to "*¿Por qué? Dime por qué?*") as a key tool to encourage home language use in reasoning. He also

Figure 9

Student Groups' Collective Note and Math Journal



learned to prioritize contextually relevant tasks, selecting the job comparison task as a "good life skill" and noting in reflection that money-related contexts enhanced class engagement. These results contribute to discussions on creating cognitively and linguistically rich learning experiences, irrespective of the teacher's linguistic background (I & Martinez, 2020).

Research on EBs' linguistic FoK is limited (Hunter, 2022), and often positions language as a challenge rather than a crucial resource for accessing and shaping mathematical problem solving (Wilson-Lopez & Acosta-Feliz, 2022). Our findings address this gap by illustrating how even monolingual mathematics teachers can learn to notice and leverage students' linguistic FoK. The CSPD cycles enabled the teacher and research team to collaboratively exchange knowledge and resources. Simultaneously, the 5-Act Task framework offered specific pedagogical entry points for teacher growth. For example, the Notice and Wonder activity in Act 0 and the explicit call for student-led translanguaging (e.g., home language reading, presentations) in Acts 1 and 4 provided a clear framework to leverage linguistic assets. Incorporating students' linguistic repertoires fosters inclusive pedagogy (García & Wei, 2014). Specifically, the translanguaging strategies outlined, such as reading problems aloud or using preferred languages for discussion, provide actionable tools for both monolingual and multilingual teachers to support their EB students. Our study differs from literature focusing primarily on family as the source of FoK (González et al., 2005; Moll et al., 1992) by emphasizing the teacher's role as an insight provider within the CSPD model. Teachers are uniquely positioned to recognize, interpret, and integrate FoK into instruction (Civil, 2016; Hedges et al., 2011) because of their daily interactions with students. Their understanding of EBs' linguistic resources, cultural backgrounds, and prior mathematical experiences is instrumental for designing relevant, cognitively demanding lessons (Moschkovich, 2013). By requiring teachers to provide student insights to shape lesson design, the study positions teachers as ethnographers (Turner et al., 2013), ensuring the systematic integration of linguistic and cultural resources. This highlights the necessity of viewing teachers as both learners and knowledge brokers who successfully bridge the gap between students' FoK and instructional rigor.

This study demonstrates that collaborative situated professional learning can effectively shift teaching practices from low-rigor mathematics instruction lacking FoK integration to high cognitive demand instruction rich in FoK. This simultaneous integration is critical because leveraging FoK and cognitively demanding tasks boosts student agency, positioning students as knowledge co-creators who confidently explore mathematical thinking (Aguirre et al., 2012; Gutiérrez, 2013; Stein et al., 2009). For EBs, this culturally rooted approach fosters translanguaging spaces (Fu et al., 2019), enabling them to use their full linguistic repertoires to access challenging concepts, develop academic language, and engage in rich mathematical discussions unconstrained by rigid language policies (Moschkovich, 2013; Yi et al., 2024). Monolingual teachers, like Ms. Hunter, can facilitate this by intentionally selecting culturally relevant problem contexts; encouraging visual-based, non-mathematical observations; and inviting student-led translanguaging and diverse expressions beyond verbal English (Civil, 2016). Ultimately, this approach promotes equity by positioning EBs as competent mathematical thinkers, supporting both their cognitive and linguistic development. The findings of this study, however, should be considered within certain limitations, including the small sample size, the specific local context, and the potential influence of the researcher's dual role; future research should address these by including a larger and more diverse sample and using longitudinal designs to mitigate researcher influence.

Implications for MTEs

Our findings suggest that the CSPD model is an effective co-teaching framework for inservice teacher education, as demonstrated by the teachers' instructional shifts, such as increased attention to students' linguistic FoK, developed through collaborative planning, co-teaching, and reflection. Mathematics teacher educators (MTEs) can integrate this model into PD sessions to foster teacher growth through collaborative practices. Additionally, the 5-Act Task framework is valuable for leveraging students' FoK, particularly Acts 0 and 4, which promote EBs' access to rigorous mathematics. MTEs who incorporate this framework into curricula should emphasize these critical acts.

To adapt the CSPD model for preservice teachers, MTEs can systematically collect information about preservice teachers' students' FoK using structured questionnaires or by involving preservice teachers' cooperating teachers in co-planning. Because teachers in this study initially overlooked some FoK practices, we recommend a questionnaire to help PSTs intentionally and systematically reflect on student cultural and linguistic resources during planning. These approaches allow preservice teachers to prioritize the use of students' FoK while they engage in the CSPD cycle. The CSPD cycle and 5-Act Task framework can also effectively guide instructional coaches, fostering a teacher's ability to notice and respond to *all* students' mathematical thinking. Although studied in high school, the underlying structures are anticipated to be relevant across all grade levels, ensuring that every student's unique mathematical voice is not only heard but leveraged as a cornerstone of their learning.

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