Practice Makes Progress in Mathematics: A Research to Practice Summary

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ABSTRACT

This research-to-practice article supplements the research article Practice Makes Progress: Leveraging Practice-Based Teacher Education in Mathematics Pedagogy Courses for Primary Grade Learners published in the journal The Dialog. This article presents suggestions based on a research study that provided a research-based framework, Inclusive and Equity-based Mathematics Teaching (IEBMT), and examined how future teachers (referred to as teacher candidates) effectively planned for and taught mathematics activities in kindergarten classrooms. This work is relevant to early childhood education professionals since research supports benefits in using inclusive and equity-based practices when teaching mathematics.

KEYWORDS

Early childhood education, elementary education, mathematics education, practice-based teacher education, problem solving

Classrooms today include a more diverse group of students than ever before, which includes children from varied linguistic, socioeconomic and cultural backgrounds (Domingo-Martos et al., 2002). It is critical that programs that prepare and support future and current early childhood educators adequately help individuals teach classrooms of young children that are increasingly diverse. Additionally, the number of individuals in early childhood education programs who demonstrate learning differences continues to increase (Schaeffer, 2023), requiring early childhood education professionals to have background knowledge and experiences supporting learners who have learning differences.

Further, in an era where student learning and achievement data continues to be a focal point, student achievement data continues to show discrepancies between students based on their cultural and linguistic backgrounds across all grade levels (Domingo-Martos et al., 2022; Musu-Gillette et al., 2017).

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Early childhood educators need support and adequate resources to effectively teach all learners regardless of students' linguistic and cultural backgrounds.

Inclusive and Equity-Based Mathematics Teaching: What is It?

The ideas included in inclusive and equity-based mathematics teaching (IEBMT) come from research on teaching mathematics to learners from diverse backgrounds as well as children who demonstrate learning differences. IEBMT has two main pillars or parts: 1) Access to grade-level aligned, research-based experiences and 2) Opportunities for the exploration of problems embedded in meaningful contexts. Table 1 describes aspects of IEBMT.

What We Know about Educator Preparation Programs

Experts who conduct research and influence policy have made recommendations for course work for teacher candidates to align with the work that they do in schools for clinical experiences (Putman & Polly, 2021; Zeichner, 2021). Early childhood TCs who hope to work with primary grade learners need ample experiences working with and learning about children in clinical practice settings in classrooms (Matengu et al., 2020; Polly, 2021).

Practice-Based Teacher Education

Practice-based teacher education (PBTE) is a process used to describe four phases to prepare TCs to learn about and enact research-based pedagogies (Grossman et al., 2009). Table 2 describes the four phases of PBTE: Learn, Practice, Enact, and Reflect (McDonald et al., 2013). In a nutshell, TCs learn about a research-based pedagogy, plan to use that pedagogy and practice using it, then they go and use the pedagogy with children, and finally reflect on their experiences (Colonnese & Polly, 2022).

Table 1

Aspects of Inclusive, Equity-Based Mathematics Teaching

Pillar	Aspect	Description
Access to grade-level aligned, research-based experiences	Alignment to grade level content	Learners should engage in activities aligned to current grade-level Standards (Gutiérrez, 2009; NCTM, 2014; Unbound Ed, 2021). Connect concepts prior to grade-level Standards to grade-level concepts (Tomlinson, 2017)
	Access to research- based experiences	Learners will engage in activities that are aligned to research-based teaching practices proven to increase student learning and achievement (Cioè-Peña, 2017; Gutiérrez, 2012).
Opportunities for the exploration of problems embedded in meaningful contexts	Exploring problems	When appropriate, learners will explore problems and select the strategies that they will use to solve problems (Buchheister et al., 2019; Sinha & Kapur, 2021). Gutiérrez (2009) describes this as Power.
	Meaningful mathematics contexts	Learners engage in activities that are contextualized in real-life situations that are meaningful to learners and build upon their cultural and academic assets (Buchheister et al., 2019; Domingo-Martos et al., 2022).

Table 2

Phases of Practice-based Teacher Education

Phase	Description
Learn	Learn research-based pedagogies by participating as learners in an example lesson, watching videos, and/or other experiences.
Prepare	Prepare to enact the research-based pedagogies with young learners. This may include selecting activities, writing lesson plans, and rehearsing/practicing teaching with peers (aka other TCs) and receiving feedback on their rehearsal.
Enact	Enact research-based pedagogies with students in a school setting. This experience may include the collection of artifacts from the enactment such as student work samples, audio recordings, video recordings, or observation notes from an observer.
Reflect	Reflect on the enactment based on TCs' experiences, student data, or recordings of the enactment.

As a result of the need to prepare future educators to use aspects of IEBMT practices with children, this study examined how two different courses used PBTE to influence TCs use of IEBMT practices.

Description of the Research Study

The study included TCs from an in-person course offered during a spring semester (Course A) and an online course offered in a summer semester (Course B). All TCs were placed in a kindergarten setting (Course A) or had spent time in kindergarten in the past year (Course B).

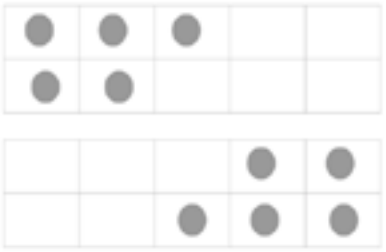
Description of Mathematics Activities

All TCs had to plan and teach a number sense activity (aka a number talk) and a 3-lesson unit about addition and subtraction word problems.

Number Sense Activity

TCs in both the in-person and the online course experienced number sense activities as learners during class. Here is an example. The author, who was the course instructor, displayed Figure 1 and then asked TCs, "What do you notice in this picture?"

FIGURE 1
Screen shot of image from number sense activity



TCs usually state ideas such as:

- "I see dots in each row."
- "I see 5 on the top and 5 on the bottom and I know that 5 plus 5 is 10."
- "I see that the bottom dots can be moved up to fill the empty boxes so that all 10 boxes on top are full to make a total of 10."
- "I went from left to right and counted by 2s. I landed on 10 which is the total."

In the course meeting after the activity, TCs spent time talking about their experiences as learners and the benefit of these activities. Part of the discussion focused on the specific questions that the instructor (the author) asked during the activity with a focus on how those questions elicited students' thinking about the mathematical concepts

embedded within the activity. In a future class meeting in both courses TCs had planned their own number talk, practiced teaching it to classmates, and received feedback from their classmates and the course instructor. TCs then went and did the activity with a small group of children and reflected on their experience.

Problem Solving Lessons

During both courses the instructor provided examples of ways to support primary grades students while solving word problems. For example, consider the word problem: There are 4 dogs in the park. Then 3 more dogs show up. These scaffolds that were shown to TCs included asking questions about the problem to guide students through the problem-solving process and providing them with a number path and hands-on counters to help students who need help keeping track of the numbers in the problems (Figure 2).

The instructor walked through the process with TCs in the following way:

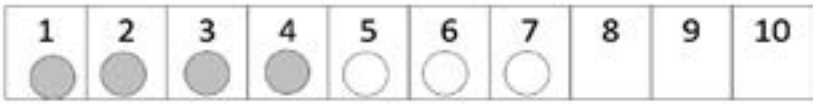
- Instructor: I want us to think about this situation. There are 4 dogs in the park. Then 3 more dogs show up.
- Instructor: How many dogs are in the park?
- TCs: There are 4.
- Instructor: How can we use our counters to show that?
- TCs cover the numbers 1, 2, 3 and 4 on the number path.
- Instructor: What is the action in our problem?
- TC: 3 more dogs showed up.
- Instructor: Use your counters to show the 3 dogs that showed up.
- TCs put counters that are a different color on the numbers 5, 6, and 7.
- Instructor: The question we are going to answer is "how many dogs are now in the park? What is the answer?
- TC: The answer is 7.
- Instructor: How do you know?
- TC: I have 4 counters and 3 counters. That is a total of 7.

TCs then spent time during a class meeting creating word problems to use in each of their three lessons. The template that was given to students required five word problems per lesson. TCs were required to create an opening word problem and then four follow up word problems. TCs were asked to create two of the four follow-up problems to be easier than the opening problem, meaning the numbers were smaller OR there would be more guidance from the TC while teaching young learners. Additionally, two of the follow-up problems were expected to be more challenging than the opening problem with larger numbers and possibly focusing on the use of pictures instead of hands-on manipulatives and less teacher guidance. After students created word problems, they had a class session where they practiced teaching one of their word problems using the process that was detailed above. Similar to the number sense activities, peers provided feedback.

Findings

The findings focused on two areas: 1) TCs provided access to grade-level aligned research-based experiences and 2) TCs providing opportunities for young children to explore problems embedded in

FIGURE 2
Picture of Number Path and Counters



meaningful contexts.

In the first area, TCs effectively planned for and ask questions during the number talk that gradually increased in difficulty- from asking students to share their strategy towards more high-level questions where TCs asked young children to explain why they chose specific strategies. Examples of these questions are: "How is this strategy of finding the total number similar to the strategy we saw earlier?" and "How do you know that your thinking is correct?" TCs also effectively planned for and taught activities where learners used manipulatives and visuals. All TCs were aligned with the desired pedagogies by using manipulatives such as counters or cubes along with Number Paths (Figure 2). While TCs demonstrated some degree of fidelity to the desired pedagogies by planning for and using manipulatives such as counters and cubes in their Practice activity. TCs, though, reported a lot of uncertainty across both courses on how to help students transition from manipulatives to pictures.

In the second area, TCs effectively wrote and taught word problems that were embedded in contexts that were meaningful and relevant to young learners. These problems were about topics that young learners could relate to, such as Latin American food and cultural events for students whose family was from Latin America. However, there were mixed findings on TCs during their teaching. TCs were supposed to pose word problems and guide young children's mathematics work by asking questions; however, a few of the TCs directly taught children with step-by-step instructions that children just mimicked and copied.

Tips and Suggestions Based on This Study

This study found that the practice-based teacher education (PBTE) activities such as Learning, Preparing, Enacting, and Reflecting helped support teacher candidates (TCs) enactment of Inclusive and Equity-Based Mathematics Teaching (IEBMT) with kindergarten learners. Specifically, TCs were able to plan mathematics activities that were relevant to learners and appropriately aligned to their grade level and TCs. Here are some takeaways:

- Practice does make progress. TCs did number talk activities and problem-solving activities as learners, planned their own activities, and then did practice teaching before using them with children. This practice helped TCs become more comfortable with the activities and how to teach them.
- Focusing on questioning. TCs demonstrated, in a lot of instances, their skills in asking questions about children's math ideas as well as follow-up questions that included more how or why questions about children's use of strategies (see Colonnese et al., 2022).
- Guiding versus directing children. While the approach of practice-based teacher education helped TCs, some TCs reverted back to directing students' process of solving word problems when they sensed that children were struggling instead of guiding them. A lot of practice and discussion may be needed with TCs related to supporting children's problem solving when they are striving to figure out what to do with a word problem.

"Practice does make progress. TCs did number talk activities and problem-solving activities as learners, planned their own activities, and then did practice teaching before using them with children."

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