Equity-Based Mathematics Teaching Practices in Pre-Service Teachers' Lesson Plans

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As K-12 classrooms have become more culturally and linguistically diverse, it is important to prepare pre-service teachers (PSTs) to develop their knowledge of designing and implementing instruction based on equity-based mathematics teaching practices (EMTP). We analyzed 41 PSTs' lesson plans designed in a middle school mathematics methods course from five semesters. A theoretical thematic analysis revealed which EMTP categories appeared in the lesson plans. Findings indicate that PSTs seem comfortable and familiar with some categories, but they need support with other categories. In addition, methods courses should focus on EMTP so that PSTs strike a balance between EMTP categories by engaging students in non-routine, high cognitive demand tasks and by supporting diverse learners in mathematics classrooms.

Keywords: Pre-service teachers, Equity-based mathematics teaching practices, Culturally responsive mathematics teaching, Teaching mathematics for social justice

Objectives

In the U.S., the K-12 classrooms have become increasingly diverse and there is a need to prepare mathematics teachers who can cater to the learning needs of these students while maintaining high standards of teaching and learning (Aguirre & del Rosario Zavala, 2013; Association of Mathematics Teacher Educators [AMTE], 2017; National Council of Teachers of Mathematics [NCTM], 2014). In this regard it is important to prepare pre-service teachers (PSTs) to design and implement instruction based on equity-based mathematics teaching practices (McGraw et al., 2023; Moldavan & Gonzalez, 2023).

Equity-based mathematics teaching practices (EMTP) are pedagogical actions that seek to challenge existing educational norms and allow students to actively participate in learning mathematics (Chao et al., 2014). Such teaching builds on students' strengths, connects mathematics learning to students' knowledge and experience, and engages students in solving problems that are relevant to them (Aguirre, 2009; Aguirre et al., 2012; Civil, 2007; Gutiérrez, 2002; Gutstein, 2006; Turner et al., 2012). EMTP can aid in the development of students' positive mathematics identities so they see themselves as doers of mathematics (Berry, 2008; Boaler, 2002; Martin, 2000, 2009; Stinson, 2008). There is a need for teachers to develop classrooms where students can see themselves as mathematicians (Aguirre et al., 2024).

Our study focuses on instances of EMTP included in the lesson plans. The specific research question is: *What EMTP can be gleaned from PSTs' lesson plans designed to connect mathematics and social justice learning goals?* For our study, we analyzed 41 PSTs' lesson plans designed in a middle school mathematics methods course. We engaged the PSTs in developing mathematics lesson plans that included both mathematics and social justice goals.

Theoretical Framework

Mathematical identity can be defined as beliefs that students develop about their own ability to use mathematics effectively and in various contexts, versus being unable to do mathematics (Aguirre et al., 2024). Identity itself can be defined as the stories people tell about themselves or that others tell about them (De Fina, 2015). Students' identities outside of school can play a

powerful role in how they perceive themselves as students, both in general and specifically as mathematics students (Martin, 2000).

Aguirre and colleagues (2013) defined five EMTP that can help develop students' mathematics identities. These practices are: Going deep with mathematics; Leveraging multiple mathematical competencies; Affirming mathematics learners' identities; Drawing on multiple resources of knowledge; and Challenging spaces of marginality. These practices can overlap and work together to support students in feeling a sense of belonging inside mathematics classrooms (Allexsaht-Snider & Hart, 2001; Espinosa, 2023).

Here we provide a brief description of each of the five EMTP. Going deep with mathematics suggests that mathematics lessons include high cognitive demand tasks that allow students to become mathematically proficient. Leveraging multiple mathematical competencies means valuing students' areas of strength in terms of mathematics, and providing learning opportunities where students with various strengths can serve as resources. Affirming mathematics learners' identities refers to instruction that can support the development of a student's mathematical learning identity. For example, the teacher encourages perseverance in problem solving, removes a focus on speed in computation, allows students to fix their mistakes and frames mistakes as opportunities for learning. Drawing on multiple resources of knowledge encourages a teacher to perceive the student as a source of knowledge and experiences and use the student as a resource for teaching and learning mathematics. Students might have mathematical, cultural, linguistic, interest-based, family or community knowledge. The teacher can use this knowledge to connect mathematics to real life experiences and encourage students to solve problems connected to their lives. Challenging spaces of marginality stresses that teachers let go of the traditional mathematics teaching practices with a focus on lecture and also to question biases about who should be in a mathematics classroom. According to this practice teachers should acknowledge the various ways in which students can be mathematicians and expand their own vision of what it means to do mathematics.

Methods or Modes of Inquiry

We employ Phenomenology to identify instances of equity-based practices in the PSTs' lesson plans. Phenomenology allows us to analyze the lesson plans to unpack PSTs' perceptions about EMTP based on the activities included in their lesson plans (Moran, 2000). In other words, we analyzed our data while PSTs' were not explicitly asked to design their lesson plans based on the EMTP. By doing so, we were able to obtain spontaneous, not intentional, patterns of PSTs' use of EMTP in their lesson plans.

The study took place at a mid-sized university in the Mid-Atlantic region of the United States inside a middle school mathematics methods course. The course was geared towards pedagogy of mathematics and specially focused on culturally responsive mathematics teaching and teaching mathematics for social justice. PSTs were asked to develop lessons that included both mathematics and social justice goals. They were asked to include at least one social justice standard (Learning for Justice, 2022) as a social justice goal. PSTs were also required to include supports for emergent multilingual learners (EMLs) in their lesson plans.

Participants were 41 PSTs enrolled in the methods course during Spring 2021, Fall 2021, Spring 2022, Fall 2022, and Spring 2023 semesters. PSTs' lesson plans from these semesters were analyzed. Since our research question is explicitly related to specific teaching practices, theoretical thematic analysis was employed to report patterns within our data (Braun & Clarke, 2006). Due to our focus on equity-based practices, the lesson plans were analyzed based on

categories of Aguirre et al.'s (2013) five equity-based mathematics practices. We perceived each of the practices as follows:

Table 1. Description of five equity-based mathematics teaching practices.

Category	Description
Going Deep with Mathematics	Student engagement in high cognitive demand tasks, generating questions, using tasks connected to student interests, engaging students in problem solving and applying mathematical concepts.
Leveraging Multiple Mathematics Competencies	Tasks with multiple entry points, engaging students in problem solving, using various mathematical representations, discussions, collaboration and learning from strengths of other students.
Affirming Mathematics Leaners' Identities	Activities that allow student's confidence in their math ability to increase, developing persistence in problem solving, providing various ways for students to demonstrate their math prowess.
Drawing on Multiple Resources of Knowledge	Using students as a resource for learning mathematics, e.g., using data, using students' own knowledge to come up with ideas, themes, conjectures, working in pairs or groups, using peers as a resource.
Challenging Spaces of Marginality	Encouraging marginalized students to become confident math learners, positioning students as math experts, making students feel welcomed in math class, incorporating student interests.

Results

In this section we provide an account of the EMTP that we gleaned from the body of the lesson plans, where we did not specifically ask the PSTs to use these practices. We share what each practice looked like, and provide examples of what was included in the lesson plan. We noticed that Drawing on multiple resources of knowledge was evident in a majority of the lesson plans (29), followed by Leveraging multiple mathematical competences (21), and Affirming mathematics learners' identities (12). We only noticed a few instances of Going deep with mathematics (5) and Challenging spaces of marginality (4).

Drawing on Multiple Resources of Knowledge (29)

PSTs' lessons that included this practice, positioned peers or students themselves as learning resources, followed by an academic resource like a book or handout. Some examples of activities where students employed their peers as a resource included: Think-Pair-Share; students will listen to other students' letters and engage in conversation about free and reduced lunch; teacher will ask if any other group solved the problem differently, if so have them share. These examples take the focus away from the teacher as the only resource of knowledge, guidance or support, and students can learn to depend on their peers to solve problems. Likewise, examples of students seeing themselves as decision makers were: students will be tasked with creating their own mini poster based on at least one of their ideas; students will participate in mathematical modeling and use their own ideas and views to create problems about the picture on the Jamboard; students will create a blueprint of an outdoor space of their choosing … they will use

transformations to make images of the shape around the blueprint; students will research local organizations and choose one that the money in the girl scouts activity will go to; students will get their data for this activity from the United States Interagency Council on Homelessness website, students will decide what data they want to use for their argument. These examples demonstrate the ways in which PSTs perceived classroom activities that allow students to see themselves as experts who are able to take charge when solving a problem.

Leveraging Multiple Mathematical Competencies (21)

PSTs included various forms of activities in their lessons to draw on students' mathematical competencies. For example, allowing students to work independently on activities such as the number line activity, writing ideas on an index card, collecting their own data and then analyzing it. PSTs also planned for students to engage in group work to discuss ideas, represent algebraic expressions, do practice problems, come up with multiple representations or compare their own work with a partner. Planning for both group work and individual work may allow students who prefer a specific working style to have a chance to participate in class. Other activities that could allow the teacher to leverage multiple mathematical competencies were: making and presenting posters, students coming up with various mathematical representations, direct instruction, making comparison between graphs to name a few.

Affirming Mathematics Learners' Identities (12)

PSTs' lessons paid attention to students' interests and we coded instances of student interest as Affirming mathematics learners identities. An example of such an activity is the Minecraft activity where students research and brainstorm if squares and cubes are the best shape for Minecraft, create 3-5 argumentative points that defend their side, then draft a letter of persuasion to Minecraft creators to defend their ideas. Another example includes students choosing a resource from a town map that they wish to move to benefit more people in their area, then students recreate the town map with the resource in its new location (with correctly identified and plotted ordered pair) on a poster or Google Slide, and defend why that resource needs to be placed in that position. These examples point towards PSTs employing students' interests in real life scenarios to help them engage in doing mathematics. In addition, PSTs also supported student participation in the classroom by encouraging students to ask questions and have discussions, assigning roles during group work so that all students get a chance to participate.

Going Deep with Mathematics (5)

While we assumed this would be the most commonly observed equity-based practice, we only coded five instances of Going deep with mathematics. The lesson plans included high cognitive demand tasks, real-world applications, and productive struggle to be in this category. While all the lesson plans included real-world applications we only coded instances where the tasks were designed to maintain a high level of cognitive demand for the students.

Challenging Spaces of Marginality (4)

Although we were expecting to notice little to no instances of this EMTP in the PSTs' lesson plans, we coded four instances of Challenging spaces of marginality. Examples for this practice include: teacher will give some students a differentiated version of the worksheet; teacher will ask guiding questions if students are struggling; students will individually work on their project, however, they will engage in mathematical conversations with their peers and encourage one another through the process; students should be working to get through the math and reflection

with one another as mathematicians do when they are attempting to solve a problem. We noticed that all instances in this category were ways to differentiate instruction.

Discussion and Conclusions

We had sought to learn what PSTs' lesson plans reveal about their use of EMTP. The lessons included mathematics and social justice goals. In addition, PSTs were asked to include supports for EMLs. The EMTP that PSTs included in the body of the lesson plans reveal teaching practices that they were comfortable and/or familiar with. The highest instance of Drawing on multiple resources of knowledge points towards PSTs' knowledge of this practice. Likewise, including activities that would leverage multiple mathematical competencies was another practice with which PSTs seemed to be familiar.

Affirming mathematics learners' identities was an area that PSTs needed support with. This means PSTs need to learn about supporting the development of students' mathematical identities. PSTs' coursework should highlight that developing students' mathematical identity requires teachers to pay attention to students' lived experiences, their feelings towards mathematics and their sense of belonging in mathematics classroom (Darragh, 2013; Kaplan & Garner, 2017). Teachers need to maintain a balance between teaching the content and supporting the development of students' mathematical identities by catering to the learning needs of students and creating inclusive classroom environments (Miller-Cotto & Lewis, 2020).

Our PSTs also needed support with both Going deep with mathematics and Challenging spaces of marginality. According to the Culturally Responsive Mathematic Teaching framework developed by Zavala and Aguirre (2023), teachers need to provide opportunities for students to engage in non-routine, high cognitive demand tasks that foster the development of their analytical and critical thinking skills (Smith & Stein, 1998). Developing deep understanding of mathematics is a major goal of equity-based mathematics teaching practices (Aguirre 2009; Gutstein 2006). Students, in particular EMLs, might need various supports and scaffolded instruction for successful engagement with such tasks (Anhalt, 2014; Turner et al., 2024).

With regards to Challenging spaces of marginality we found that our students' lessons included supports that could best be seen as differentiation. Differentiation can be understood as ways in which teachers make instructional decisions based on students' readiness, their interests and learning needs (Tomlinson, 2017). This includes developing a classroom community where teacher pays attention to excellence in instruction, uses assessment to make instructional decisions regarding students' learning needs and pays attention to tasks that are meaningful to the students, connecting the content to the real world (Hocket & Doubet, 2021). While there is overlap between differentiation and Challenging spaces of marginality, there needs to be a special focus on making mathematics classrooms inclusive spaces for marginalized students (Aguirre et al. 2024). This includes teachers becoming aware of their own biases and engaging in activities that challenge "deficit thinking, segregation and harm" (p. 65).

Our findings indicate that a greater focus on EMTP in PSTs' methods courses is needed to help them intentionally include these practices in their lesson plans. Devoting time in the methods courses to unpack these pedagogical ideas could allow the PSTs to ask questions and learn how to identify these practices during their field experience. We noticed that PSTs included aspects of EMTP that were highlighted in their courses. Guided by the findings, our team will focus on developing method course resources especially focusing on equity-based teaching practices that were missing, or not well attended to in these lessons. We will also focus on supporting field experience personnel to learn about these pedagogical ideas so they can highlight these practices in their classrooms for PSTs during field experience.

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