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# Responsible Integration of Artificial Intelligence into Pedagogies of Practice in Mathematics Teacher Education

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Practice-based teacher education emphasizes the development of teaching skills through active engagement in core instructional practices. Grossman et al. (2009) identify three pedagogies of practice: representations, decompositions, and approximations of practice. These pedagogies of practice can serve as foundational tools for supporting mathematics teachers at all stages of their careers, including both aspiring and practicing teachers. These pedagogies can help mathematics educators gain a deep understanding of teaching and develop their teaching capabilities and pedagogical reasoning by providing opportunities to observe, analyze, and rehearse teaching moves. Representations of practice make teaching practices visible; decompositions of practice involve breaking complex teaching practices into learnable components; and approximations of practice provide opportunities to enact these components in a supportive environment. With the emergence of artificial intelligence (AI), these pedagogies can be enhanced to provide dynamic, personalized, and scalable learning experiences. As AI becomes increasingly influential in educational contexts, it is essential to consider not only its potential but also its ethical and responsible integration. In mathematics education, this means ensuring AI is used to support equity rather than reinforce existing disparities, and that its implementation is guided by critical, research-informed perspectives.

In this research commentary, we aim to explore how AI can be responsibly integrated into pedagogies of practice to support the ongoing development of mathematics teachers. For each of the three pedagogies of practice, we explore some of the current ways in which the pedagogy is being taken up in the field, provide examples of the possibilities for enhancement by integrating AI, and discuss some of the demands of responsible integration. We close the commentary by unpacking a set of considerations for the responsible integration of AI into pedagogies of practice. While we separate the pedagogies in this manuscript, we acknowledge that they are often designed and used together as parts of cycles of enactment and investigation (e.g., McDonald et al., 2013).

## Representations of Practice

Representations of practice are artifacts, such as videos, transcripts, lesson plans, and samples of student work, that showcase the work of teaching. These artifacts enable teachers to observe cases of mathematics teaching and learning (e.g., Gonzalez & Moldavan, 2025). Seeing a representation can help educators decompose a practice, and, in some cases, serve as a springboard into an approximation of practice (Danielson et al., 2018). Before the widespread use of AI, real representations were static and limited by what was captured in classrooms or other interactions with learners. While video has long been central to developing teachers' professional vision, supporting their ability to notice and interpret significant classroom interactions (Sherin, 2003), representations are not limited to real classroom footage. Hypothetical and designed artifacts, such as fictional student work samples (e.g., Shaughnessy & Boerst, 2018), planted errors (Campbell et al., 2020), constructed case studies (e.g., Bondurant et al., 2025; Gutiérrez, 2017; Marshall et al., 2020), and text-based lesson plays (Zazkis et al., 2009), also serve as powerful representations that invite teachers to engage deeply with instructional decision-making. These representations can encourage teachers to reason about what might happen in a classroom and why, and to consider multiple possibilities for responding to student thinking.

Some representations foreground issues of power, identity, and equity in mathematics teaching. For example, Gutiérrez's (2017) "In My Shoes" activity immerses preservice mathematics teachers (PSTs) in narrated experiences of marginalized learners to support their development of *political conocimiento*, a form of knowledge that helps teachers recognize and respond to structural inequities in mathematics classrooms. Similarly, the "Critically Analyzing and Reflecting on Difficult Situations (CARDS)" tool (Marshall et al., 2020) and "equity vignettes" (Bondurant et al., 2025) can support mathematics teacher educators (MTEs) in designing equity-focused representations that allow teachers to rehearse responding to complex, real-world dilemmas involving power, identity, and access in mathematics education.

AI can enhance representations by customizing them to individual teacher learning trajectories. For instance, the MTE can ask AI tools to curate cases that highlight a particular pedagogical dilemma or are aligned with a teacher's specific professional goals. Education-focused AI tools, such as Colleague AI (n.d.), which complies with FERPA requirements, can generate text-based cases, such as simulated student work or dialogue, that mirror the complexity and diversity of real classrooms while allowing MTEs to control for specific instructional challenges. General AI tools can also be used to craft relevant mathematics tasks (Berryhill et al., 2024; Nucci et al., 2024). Moreover, AI tools, like Mursion (n.d.), can also generate more authentic representations that include audio, images, and even video components. With AI enhancements, digital clinical simulations, like Teacher Moments (n.d.), could offer customizable scenarios delivered through a scalable platform.

However, the use of AI in designing and delivering representations must be guided by critical, research-informed perspectives to ensure that such tools do not reinforce biases or inequities (Ataide Pinheiro et al., 2025; Bondurant & Reinholz, 2023; Gómez Marchant & Hardison, 2024). Ethical and responsible integration of AI requires careful attention to whose perspectives are represented, how data are used, and whether the cases reflect the cultural and linguistic diversity of real classrooms. Moreover, AI-created representations, such as ChatGPT-generated tasks, may reduce the cognitive demand of the task or produce inaccurate solution strategies (Sapkota & Bondurant, 2024). Taken together, these examples illustrate how AI can expand and customize representations of teaching, but they also underscore the need for deliberate design and critical reflection to ensure that AI-generated artifacts support equity and authentic learning rather than reinforce biases or narrow perspectives.

**Decompositions of Practice**

Decomposition of practice involves breaking complex teaching activities into smaller, analyzable elements to make them more learnable for teachers. In mathematics teacher education, this work has traditionally relied on analytic frameworks, tools, and rubrics that articulate the constituent parts of ambitious and equitable teaching practices (Horn & Garner, 2022), for example, identifying moves associated with eliciting student thinking, probing for justification, or making connections across representations (Grossman et al., 2009). Teachers often engage in collaborative sensemaking to determine which elements of a practice to highlight, drawing on expert intuition, classroom examples, and shared professional judgment. Decompositions typically occur alongside representations of practice, such as videos, transcripts, or samples of student work, through which teachers examine how specific discourse patterns, questioning strategies, or instructional decisions unfolded. Teachers often analyze these decomposed elements together before and/or after engaging in an approximation of practice or an authentic teaching experience. The peer feedback and guided reflection that occurs during decompositions of practice can help teachers build a shared understanding of what focal practices look and sound like when they are enacted effectively and subsequently set goals for their future enactments of the practices.

Today, AI has the potential to automate and enhance the decompositions of practice. AI can help teachers analyze representations of both teaching and learning. For example, AI could be used to identify patterns in teacher moves and categorize them by function, such as eliciting and interpreting student thinking. AI can also highlight inconsistencies or missed opportunities in a teacher's instructional decisions, helping them better understand areas for growth, such as providing more opportunities for students to talk (Adams & Middleton, 2025; MPowering Teachers, n.d.). In the future, AI may be able to use decompositions of practice to provide teachers with real-time feedback on their enactment of particular practices. This would allow teachers to recognize and refine their practice as it unfolds.

Yet, as with other applications of AI, these innovations must be guided by ethical considerations and critical, research-informed perspectives. Given that large language models (LLMs) may only be about 75% accurate (Datta et al., 2023), MTEs must be vigilant about reviewing the accuracy of AI-generated feedback. Moreover, MTEs should carefully consider whose norms and values are reinforced in the data used to train the LLMs. While AI can enhance teachers' ability to analyze and refine instructional moves, the accuracy, interpretability, and equity implications of AI-generated analyses highlight the importance of guided, research-informed oversight.

**Approximations of Practice**

Approximations of practice can provide opportunities for teachers to rehearse teaching strategies in controlled, low-stakes environments (Colonnese et al., 2024; Sapkota & Max, 2023; Wilkerson Lee et al., 2025). Commonly used formats include peer teaching rehearsals (e.g., Smith, 2025; Roberts et al., 2025), coached rehearsals (e.g., Lampert et al., 2013), microteaching (e.g., Venenciano et al., 2025), and tutoring (e.g., Lamberg & Goyer, 2025). These approximations allow teachers to try out specific elements of practice, such as orchestrating productive discussions (Mikeska et al., 2022; Smith & Stein, 2018), without the full complexity of managing a real classroom. Teachers can engage in live rehearsals where an MTE plays the role of a student (e.g., Shaughnessy et al., 2025). They can also practice in a digital simulation platform, such as Teacher Moments (Barno et al., 2025; Benoit et al., 2025; Hillaire et al., 2022). Moreover, approximations include mixed-reality digital teaching simulations where student avatars controlled by a human-in-the-loop respond in realistic ways to instructional moves, creating an authentic rehearsal experience (Bondurant & Amidon, 2021; Howell & Mikeska, 2021).

AI-mediated approximations can be configured to present a wide range of instructional scenarios, such as diverse student profiles, whole-class or small-group interactions, and authentic classroom dilemmas such as eliciting student thinking, addressing misconceptions, or managing participation inequities (e.g., Authentech Practice, n.d.). Recent empirical and exploratory work in mathematics teacher education suggests both promise and important limitations. For example, Son et al. (2024) used an AI-based chatbot that functioned as both a virtual student and mentor, enabling PSTs to rehearse responsive questioning and revealing four distinct questioning profiles, while also showing that PSTs' self-assessments did not always align with observed interaction quality, highlighting the need for structured guidance when interpreting AI-generated feedback. Zhuang and Zhang (2025) implemented two GenAI-integrated activities, a question-generation task using ChatGPT-4.0 and simulated student interactions using a custom "Student GPT," and found that PSTs' perceptions of these tools became more positive over the semester as their prompt-writing skills and familiarity improved, with results underscoring the importance of structured guidance, formative feedback, and sustained engagement when integrating AI into questioning practice.

Exploratory studies of GenAI-enhanced simulations (e.g., Hong et al., 2025; Mikeska et al., 2025) show that embedding LLMs into virtual or mixed-reality environments can support PSTs' development of instructional decision-making, communication, and eliciting-thinking practices, and can serve as a formative assessment tool for examining teaching moves. At the same time, these projects identify design limitations, including cognitive load, interface constraints, and the need for instructional scaffolding, that must be addressed to ensure these simulations function as effective, scalable approximations of practice. More targeted exploratory work on automated post-rehearsal feedback (Bywater et al., 2025) found that PSTs who received automated feedback after repeated chat-based rehearsal cycles significantly increased their use of probing and exploring questions, suggesting that teaching simulations incorporating automated feedback can meaningfully support the development of high-quality questioning practices.

Together, these studies suggest that AI-mediated approximations can expand the repertoire, accessibility, and formative potential of rehearsal experiences (Grossman et al., 2009), but they also highlight the need for careful design, instructional scaffolding, structured guidance, and ongoing human facilitation to support teacher learning, maintain responsiveness to authentic student thinking, and promote equitable practice. AI-mediated approximations can increase accessibility, fidelity, and formative feedback opportunities, yet these benefits depend on careful scaffolding, structured guidance, and ongoing human facilitation to preserve responsiveness to authentic student thinking and promote equitable teaching.

**Responsible Integration**

Taken together, the prior sections illustrate how AI can enhance representations, decompositions, and approximations of practice in mathematics teacher education. AI can provide dynamic, personalized, and scalable learning opportunities, such as curating targeted video cases, generating analytic prompts, and offering rehearsal feedback. However, these possibilities come with ethical and practical considerations: accuracy, interpretability, equity, and alignment with research-informed pedagogical goals. Each type of pedagogy presents unique opportunities and challenges, emphasizing that responsible integration requires deliberate planning and ongoing reflection.

AI-mediated systems can support interconnected cycles of learning, where observation, analysis, and practice reinforce each other. For example, teachers can observe AI-curated representations, analyze patterns of discourse using AI-generated prompts, and then rehearse teaching moves in AI-enhanced simulations with formative feedback. Yet, as highlighted in the previous sections, PSTs' interpretation of AI feedback may not always align with observed practice, AI-generated analyses may contain inaccuracies, and data biases can unintentionally reinforce inequities. These issues underscore the need for structured guidance, facilitation, and human oversight.

To help MTEs critically evaluate and implement AI tools, the following guiding questions can serve as a framework for responsible and ethical integration:

1. **Purpose and Alignment:** What is the intended learning goal for the AI-enhanced activity, and how does it align with evidence-based teaching practices?
2. **Accuracy and Reliability:** How accurate and trustworthy are the AI-generated outputs (e.g., representations, feedback, analyses), and what measures are in place to verify them?
3. **Equity and Inclusion:** Whose perspectives and experiences are represented in the AI-generated content, and how does the tool address or avoid reinforcing existing biases?
4. **Interpretation and Scaffolding:** What guidance and support are provided to help teachers interpret AI-generated feedback or analyses appropriately?
5. **Privacy and Data Use:** How are teachers' and students' data handled to ensure privacy, transparency, and compliance with ethical standards?
6. **Sustainability and Professional Judgment:** How does AI integration support, rather than replace, human judgment and ongoing professional learning for mathematics educators?

These guiding questions encourage a reflective, research-informed approach to AI integration, prompting MTEs to critically interrogate each tool before adoption and during ongoing implementation. By centering ethical considerations, equity, and human facilitation, AI can become a supportive ally in enhancing practice-based mathematics teacher education rather than a source of narrow standardization or unintended bias.

## Conclusion

The integration of AI into practice-based mathematics teacher education has the potential to transform how representations, decompositions, and approximations of practice support teachers across all stages of their careers. AI can provide dynamic, personalized, and interactive learning experiences that deepen teachers' understanding of instructional practice and strengthen essential teaching skills. By using guiding questions to critically evaluate AI tools and pairing AI with intentional human facilitation, MTEs can harness these technologies' benefits while mitigating risks of bias, inequity, or misinterpretation. Ongoing research is needed to examine both the effectiveness and ethical implementation of AI-enhanced pedagogies, ensuring that these tools function as thoughtful allies in promoting equitable, high-quality mathematics teaching and learning.

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