Leveraging the Potential of AI as a Partner in Teaching

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Rapid advancements in AI technology have motivated mathematics teacher educators (MTEs) to experiment with and engage with AI in prospective elementary and secondary mathematics teacher (PMT) learning contexts (Celik et al., 2022). Research efforts have focused on the implications of the use of AI on student learning outcomes, teacher pedagogical strategies, and the overall effectiveness of AI integration (e.g., Copur-Gencturk, 2023). We are engaged in a longitudinal research project exploring the role of AI in PMT learning environments. Our lines of inquiry include clarifying the effective integration of various AI tools for teaching mathematics, developing AI-integrated mathematical learning environments for PMTs, and examining the impact of these tools on PMTs' mathematical learning.

In the initial phase of our research (Yilmaz et al., in press), we explored how elementary PMTs perceived using Khanmigo, an AI-powered learning guide, to explore number theory concepts through rich mathematics tasks. Our analysis of PMTs' interactions with Khanmigo revealed AI can transform the nature of mathematical interactions and provide more supportive individualized learning. PMTs were comfortable sharing their challenges with Khanmigo, demonstrated a greater willingness to try problems they may have previously given up on, and embraced mistakes as learning opportunities. However, PMTs found some AI responses confusing and questioned its reliability, often seeking clarification from their instructor. Our findings indicate how engagement with AI can foster perseverance and reshape PMT's perceptions of struggle in mathematics classrooms.

We are currently conducting research focused on secondary PMTs' engagement with ChatGPT, a generative AI natural language processing model, to solve mathematical modeling (MM) tasks. The primary objective of this research is to analyze and theorize the specific ways in which PMTs (n = 15) interact with ChatGPT during MM tasks in a mathematics content course. We assigned three MM tasks as a course project to be completed outside of regular class hours. We specifically chose these tasks because they elicit multiple solution strategies and solutions (Lesh & Zawojewski, 2007), providing us ample opportunities to understand the interactions between PMTs and ChatGPT. PMTs were instructed to solve problems independently, refrain from seeking answers through direct prompts (e.g., "Help me with this math problem", "Explain this math to me"), and collaborate with AI to generate additional solutions. Finally, PMTs were required to submit a paper detailing their interactions with AI with mathematical solutions.

We developed a framework (See Table 1) to represent levels of learner engagement with AI from foundational recall to creative exploration of mathematical ideas. We then used this framework to describe PMTs' engagement with ChatGPT.

Table 1

Levels of Learner Engagement with AI

Engagement Level	Description
Foundational	• The interaction involves prompts/responses with a focus on recalling a mathematical formula, procedure, or facts. • Prompts/responses serve a specific purpose and might overlook erroneous information. • The interaction is focused on task completion but may not yield a correct solution.
Constructive	• The interaction involves prompts/responses with a focus on explaining mathematical concepts, processes, or relationships. • Prompts/responses involve elaboration and clarification and consider all relevant information. • The interaction is focused on collaborative development of a solution strategy and may lead to a correct solution.
Creative	• The interaction involves prompts/responses with a focus on explaining mathematical concepts, processes, or relationships. • Prompts/responses involve mutual exploration of mathematical concepts, considering all relevant information. • The interaction extends beyond the correct solution, involves generalizations, and may result in creation of additional outputs or products, beyond the given information.

We also parsed PMTs' reflections pre- and post-engagement in MM with AI to inform MTE practice. In this paper, we draw from our qualitative analysis of PMTs' levels of engagement with AI (Nirmala and Yilmaz, in press) and our subsequent analysis of PMTs' reflections on their MM experiences to describe their ideas about learning and teaching with AI. The description includes quotes from PMTs, all of whom are identified by pseudonyms.

PMT's Approaches to Teaching with AI

PMTs expressed several concerns about the classroom integration of AI related to their belief that students may perceive AI as an unreliable shortcut for obtaining mathematical answers. In their pre-survey reflections, PMTs questioned whether AI could diminish the ability of their students to articulate their thought processes and to reflect on the validity of their answers. PMT Jose expressed concern that AI would "solve the problem right away. That takes the struggle away and you know, the greatest teacher is failure, so students won't learn much from AI." Additionally, PMTs perceived that AI might detract from their own efforts as teachers to promote conceptual understanding.

Despite these initial concerns, their experiences with the mathematical modeling tasks created a context in which they could formulate pedagogical strategies for teaching with AI. Several PMTs (n = 6) emphasized student-centered approaches leveraging the potential of AI to not only respond to student thinking and build

conceptual understanding but also to simulate student interactions. In contrast, some PMTs (n = 2) envisioned a more teacher-centric use of AI as a non-intelligent application of mathematics education technology.

Leveraging AI as a Partner in Teaching

PMT Lucile recognized the potential of an incorrect solution from AI to support the orchestration of productive mathematical discourse (Smith & Stein, 2018). She formulated her pedagogical approach in the context of the shelving mathematical modeling task, in which ChatGPT calculated the number of cans that would fit on a shelf without attention to the shape of the cans and the constraints of the space. She imagined using the incorrect AI solution to launch the shelving task in a whole class discussion.

> AI might be a good way to get kids to start thinking about it, cause that's similar to what the kids are gonna do. Like, what do we agree with? Do we disagree? Do we think it's functional and so you could use it as a starting place?

She connected this idea back to her own experiences with analyzing student work for misconceptions in her teacher preparation coursework. She perceived that an AI could serve as an entry point to rich mathematical conversations.

PMT Jose proposed prompting his students not only to record the ChatGPT's responses to a mathematics problem but also to explain the ChatGPT solution steps in their own words. He offered specific student prompts that he could provide students, including "What did you notice about the equation?" and "How did we get from this step to this one?" Such inquiries could foster metacognitive reflection and deeper understanding as students make sense of problem-solving strategies using the AI-generated solution.

PMT Pablo anticipated that AI could also be used to model for students that mathematics learning is more than getting correct answers. He described how he would situate AI in his classroom "to help us get to the right answer rather than just give us the right answer. We can learn from it, and we can grow from it." Since a generative AI tool learns from its interactions with students and teachers, PMT Pablo recognized that students' collaborations with AI can augment a classroom teacher's growth mindset messaging about success in mathematics.

One PMT's ideas about leveraging AI as a teaching partner extended beyond use by students. PMT Alisa suggested AI could support her in anticipating students' problem-solving approaches and addressing potential misconceptions in creating her lesson plans. She would prompt AI to simulate grade-level students' approaches to problem-solving and how she might interact with her students as she reflected, "AI is so good at emulating how humans speak and act; you can talk with AI. I want you to act like an 8th grade math student with misconceptions. I'm going to be the teacher and ask you questions." Alisa understood that using AI to anticipate students' approaches before

a lesson can help teachers to reflect on how these strategies are connected with the mathematical concepts they aim for students to learn (Smith & Stein, 2018).

Limiting the Use of AI as a Partner in Teaching

Four of the PMTs described strategies for the use of AI that were more aligned with integrating non-intelligent education technologies. PMT Brianna described how she could use AI to "represent different 3D models and in general show things that aren't as easy to model with pen and paper." She anticipated using AI to explain mathematics. Her statements that "AI should simply be a supplement!" and that "students should be using their own brain to work on assignments" suggests that she did not see student interactions with AI as productive.

Two of the PMTs shared that AI should only be used as a tool for checking the accuracy of the answers as they questioned the instructional value of AI. PMT Mario reasoned that "AI is not going to cover everything and go into all the details that you'd need to learn conceptually." This perspective is consistent with the belief that the teacher's role is to be the expert in the classroom and explain concepts to students. Another PMT (Laura) did not view AI as substantively different from an Internet search engine (e.g., Google), asserting that students could use AI to check answers or search for examples but "not for everything". Mario and Laura did not seem to perceive AI as having a role in the dynamic construction of knowledge.

Implications for MTEs

Our pedagogical shift from traditional math problems to modeling tasks provided us with new insights into the types of experiences that are most productive for encouraging PMT thinking about AI as a teaching partner. We were excited about the specific pedagogical ideas shared by many of our PMTs related to orchestrating productive mathematical discourse, encouraging a growth mindset, and simulating student-teacher interactions. Their experiences with three mathematical modeling tasks seemed to encourage PMTs to take an asset-based perspective on their students' use of AI and alleviate their concerns about cheating and incorrect answers. However, our decision to ask PMTs to engage with AI outside of class limited our insight into how our PMTs were using AI. Some PMTs found it difficult to solve tasks independently before seeking assistance from ChatGPT. In some cases, they used ChatGPT as more of a tutor than a collaborative peer. We also learned that PMTs need support in distinguishing between non-intelligent tools (e.g., Photomath, Google) and intelligent platforms like ChatGPT and Khanmigo. In our current iteration of integrating AI and mathematical modeling with PMTs, we are facilitating activities during class. This approach will allow us to monitor asking appropriate prompts and critically thinking about AI responses. As MTEs, we, too, are continuing to learn about how to use AI as a teaching partner to advance PMT understanding of the potential of dynamic learner-AI collaboration in K-12 mathematics classrooms.

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