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Learning to See Artificial Intelligence Differently: A Critical Analysis of One Preservice Teacher's Engagement in a Secondary Mathematics Content Course

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The emergence of large language models (LLMs), such as ChatGPT and Khanmigo, has generated increasing interest in their potential to support mathematical problem solving and modeling in K–16 classrooms. Artificial Intelligence (AI) tools that simply generate multi-step solutions without requiring authentic learner engagement can undercut essential problem-solving processes such as sense-making, strategy articulation, and conceptual justification (Ahn et al., 2024; Yoon et al., 2024). Recent studies show that learning gains are greatest when students are encouraged to reflect on, question, and adapt AI-generated feedback, rather than accept it passively (Gabriel et al., 2025). Such structured engagement not only improves mathematical understanding but also helps build essential technological competencies like prompt engineering and evaluative reasoning that are increasingly relevant in today's classrooms (Park & Choo, 2024).

Despite this growing evidence base, many teachers remain uncertain about how to engage AI tools in ways that support, not replace, student learning. Mathematics teacher educators (MTEs) are thus uniquely positioned to help future teachers navigate the affordances and constraints of AI tools in classroom settings. Recent interventions, such as those documented by Kim et al. (2024), show that guided experiences with LLMs can shift preservice teachers' (PSTs) thinking about AI from a passive source of answers to an active collaborator in problem-solving. Still, such shifts do not happen automatically. Effective interventions must provide PSTs with opportunities to explore AI tools within meaningful mathematical contexts, critically evaluate AI-generated outputs, and reflect on how these tools might shape their future instructional decisions. This paper contributes to this growing body of work by addressing PSTs' uncertainty and inconsistent approaches to integrating AI tools in classroom settings (e.g., Biton & Segal, 2025). We designed and implemented a structured instructional intervention to build both practical familiarity with AI tools and deeper pedagogical insight into their impact on student learning. While data were collected from a larger cohort of PSTs, in this paper, we present an in-depth analysis of one PST's experience to explore the complexity of individual learning trajectories and address this guiding question: How did one PST's perceptions of AI in mathematics classrooms shift during a structured, AI-supported intervention?

Methods

The context of the study is a mathematics content course for prospective secondary teachers. Data for the study was collected from 22 PSTs that were enrolled in the course. A key component of the course is the exploration of the use of AI tools in mathematics learning and teaching. We followed an exploratory approach to understand how PSTs engage with a specific tool, Khanmigo, when solving mathematical modeling tasks. Data was collected across three phases: pre-intervention, intervention, and post-intervention.

During the pre-intervention phase, PSTs completed a preliminary questionnaire with open-ended questions about their prior experiences with AI in mathematics, its perceived benefits and challenges, and any related training or policies they were aware of. Along with this questionnaire, they completed a shipping box design task which involves designing an efficient rectangular shipping box to hold 16 cylindrical candy containers, with the goal of minimizing the amount of cardboard. Afterward, they were introduced to Khanmigo and asked to complete the same task again outside of class using the tool. A second questionnaire captured how they used Khanmigo, what worked or didn't, and how they envisioned its potential use as future teachers.

The intervention phase included: (1) focused readings on AI in mathematics and teacher education (e.g., Kim & Park, 2025; National Council of Teachers of Mathematics [NCTM], 2024); (2) a collaborative can storage modeling task (Erbaş et al., 2016) using Khanmigo, followed by discussion on its influence on mathematical reasoning; and (3) a guided reflection using an AI engagement rubric (Naresh et al., 2024) to evaluate AI's role in shaping mathematical thinking, learning, and classroom interactions.

During the post intervention phase, PSTs collaborated with Khanmigo to complete a juice container modeling task in which involves designing a unique juice container by combining two different geometric shapes, ensuring it stands out visually while holding exactly 16 fluid ounces of juice. In addition, they completed a post-intervention questionnaire which included the original prompts along with additional questions about how Khanmigo supported or hindered their problem-solving and suggestions for improving its use in mathematics teaching.

In this paper, we present a single-case study approach to provide a theoretically grounded and analytically focused examination of one PST's (Vani) learning trajectory. A single case-design aligns with a particular form of collective logic in qualitative research: the use of an "information-rich" case to shed light on key processes that are relevant across participants (Patton, 2002; Stake, 1995). This approach allows for analytic depth rather than breadth and enables close attention to the nuances of sense-making that directly addresses the research question. Vani was selected because her responses were among the most detailed and reflective in the dataset and offered a rich account of how PSTs make sense of emerging AI tools. Her trajectory was also representative of patterns observed across the group – initial uncertainty followed by unceasingly nuanced reasoning. Her case also contained distinctive elements that provided insight into the kinds of questions and tensions several participants expressed.

Data Analysis

In Table 1, we present a thematic analysis (Braun & Clarke, 2006) with sample quotes from Vani's responses to the three questionnaires, focusing on perceived shifts across the pre-intervention, intervention, and post-intervention phases.

Table 1

Themes from Vani's Reflections Across Phases

Theme	Pre-Intervention	Intervention	Post-Intervention	Perceived Shift
Dual Nature of AI (Helpful but Risky)	*"I use it mainly to try to understand the concept if I don't understand the material. Some constraints is that it is not always 100% accurate."*	*"it never gives a direct "no" it tells the students to think of it differently and giving helpful hints."*	*"Khanmigo also broke down the math to get to the solution when it provided the formulas."*	Starts with concerns about accuracy to recognizing AI's motivational prompts and, later, its ability to scaffold problem solving.

Accuracy & Reliability Concerns	*"AI is also not always accurate if it involves complex math, but it can also be wrong in any simple math."*	*"With a lot of guesses, it will eventually give you the answer. This can be a constraint… how do you actually know if it is working?"*	*"Some constraints of using Khanmigo for mathematics learning could be providing too much information or giving away answers."*	Continued worries about AI being inaccurate; shift to a deeper concern that giving too many hints could stop students from thinking for themselves.
Pedagogical Support	*"Some potential barriers of using AI tools in mathematics classroom is how you are no longer having that communication with students"*	*"Khanmigo is asking really good open-ended questions and even going a step further to break it down step-by-step."*	*"Their interactions with Khanmigo can help them discover things that a teacher might not think of on the spot or allow students to solve the problem."*	Starts worried about less teacher-student talk, then sees AI help with clear questions and explanations, and later sees it as a helpful backup for teachers.
Student Learning & Autonomy	*"It is also a way of students cheating their way into learning."*	*"Some benefits of using Khanmigo was that it was giving hints instead of the answer right away."*	*"I discovered the proper questions and statements a learner should ask."*	First saw AI as a cheating risk, then saw it gives helpful hints, and later learned it helps by encouraging good questions and trying different problem-solving methods.

Pre-Intervention Reflections

At the start of the study, Vani expressed both interest in AI's potential and uncertainty about its place in the mathematics classroom. They saw tools like ChatGPT and Photomath as helpful for understanding concepts or offering a different perspective but were quick to point out limitations – especially when it came to accuracy. Vani shared that AI could "*lead students the wrong way, even on simple math*," and pointed to challenges in how questions were interpreted, especially when mathematics symbols or formatting were involved. These reflections showed an early awareness that while AI might be useful, it also introduced risks that could impact learning.

Vani's responses also reflected a concern about student agency. They described AI as a shortcut some might use to "*cheat their way into learning*," and worried that younger students might not even know how to enter problems correctly. The idea that technology could undermine meaningful engagement was clear, as was their belief that students still needed teacher guidance. At this point, Vani had not seen AI tools used in real classrooms beyond calculators or Desmos, which seemed to reinforce their doubts.

Structured Intervention Reflections

During the intervention phase, Vani's thinking began to shift. Their engagement with Khanmigo gave them a chance to see how AI could work in a more supportive and intentional way. Rather than focusing on AI as just a source of answers, they noticed how Khanmigo could guide thinking by asking questions and breaking problems into steps. They found this helpful and even motivational, especially when the tool responded with encouragement or offered reminders of formulas. Their reflections indicated that they no longer felt like the AI was simply handing out solutions, instead it was helping them stay engaged with the process.

At the same time, Vani remained thoughtful and critical. They noted that if someone kept prompting the AI, it might still give away the answer eventually, and this raised concerns about whether students would genuinely engage with math. They reflected on how easy it might be to keep guessing until something useful appeared, which could lead to shallow learning. Still, they began to see how AI could be useful for teachers too, especially in moments when students needed help and the teacher couldn't respond right away. They described situations where Khanmigo might offer alternative explanations or help students think through the problem in a new way, something even a teacher might not come up with "on the spot."

Post-Intervention Reflections

Vani's responses post intervention showed a clearer understanding of how to use AI thoughtfully. They spoke of learning how to ask better questions and realizing that the way they interacted with the tool shaped what it gave back. This indicated a growing sense of strategy and reflection, not just using AI but learning with it. They no longer seemed concerned about AI replacing teachers or undermining learning but rather saw it as a tool that could support students if used carefully.

Vani also began thinking about how to improve the AI experience. They pointed out that visual models and better-organized responses would help students who needed extra support. Their reflections suggested they were not only building confidence with AI but also developing a sense of responsibility for how it should be used in learning environments.

Discussion

Vani's learning trajectory reflects patterns we observed across the broader cohort: initial hesitation about accuracy and student agency, followed by increasingly nuanced engagement as PSTs gained structured opportunities to question, interpret, and refine AI-generated feedback. By situating this single case within the larger study, we see how Vani's evolving relationship with AI during the study helped us see how future teachers begin to make sense of new technologies in mathematics learning. Vani's early responses reflected uncertainty, shaped by concerns about accuracy, overuse, and fairness. These concerns were not superficial. They pointed to deeper questions about how students learn, what support looks like, and the kinds of thinking that AI might encourage or discourage.

As Vani engaged more directly with Khanmigo, their thinking began to shift. Rather than seeing the tool as simply right or wrong, they started to treat it as something that required interpretation and judgment. They became more attuned to how the tool worked, what it offered, and what it left out. This shift was not just about confidence. It reflected a growing ability to think critically about AI-generated feedback and to decide how and when to use it.

Vani also reflected on the ways in which AI shaped their own problem-solving process. In the final phase of the study, they described being more aware of the questions they asked and the way they interacted with the tool. They noticed moments when the tool's support was helpful but also recognized when it caused confusion or encouraged shortcuts. These reflections suggested a thoughtful and developing stance toward technology, rooted in a concern for meaningful learning.

Throughout the study, Vani remained focused on the role of the teacher. Their reflections returned often to the importance of student understanding, teacher judgment, and the balance between support and independence. Whether they were describing what worked well or what needed to be improved, their comments were rooted in a developing sense of what it means to teach in a way that is responsive and intentional.

Implications for MTE Practice

Vani's case allowed us to see how a prospective secondary teacher makes sense of AI in real time, through experience, uncertainty, and reflection. Vani's evolving stance, from skepticism and uncertainty to critical engagement and thoughtful reflection, reminded us that building AI literacy is not just about familiarity with tools, but about sustained interaction, reflection, and pedagogical reasoning (Walkington, 2025; Yilmaz et al., 2025).

We learned that meaningful shifts in thinking happen when PSTs are given structured opportunities to use AI tools in authentic mathematical contexts, coupled with time to reflect on both the affordances and limitations of those tools. Vani's engagement with Khanmigo showed how open-ended modeling tasks, in addition to a structured intervention created space for deeper questioning and more strategic use of AI. This finding aligns with growing calls to support PSTs in critically engaging with AI, not merely using it to get answers (Kim & Park, 2025; Naresh et al., 2024).

We also recognized that PSTs can offer insightful, grounded feedback on AI design and use. Vani's comments about clarity, scaffolding, and visual support were rooted in their developing understanding of teaching and learning, reinforcing the idea that PSTs can play a role not just as users but as reflective evaluators of educational technology (Mohamed et al., 2022; Wardat et al., 2023).

Finally, this case highlighted how closely PSTs' perspectives on AI are tied to their emerging teacher identities. Vani's reflections extended beyond tool functionality to questions about pedagogy, student agency, and the role of the teacher which resonates with research that situates AI use within larger professional and ethical considerations (Hwang & Tu, 2021; Yilmaz et al., 2025).

Conclusion

This single case offers a close view of PST's emerging engagement with AI and highlights important considerations for MTE. While we do not make generalizable claims from a single case, this study sharpened our understanding of how PSTs begin to navigate AI critically and thoughtfully. As AI tools become more present in classrooms, MTEs need approaches that help PSTs move beyond using AI for answers toward using it as a resource for reasoning, decision-making, and reflection. Our findings suggest that well-designed interventions, built around thought-provoking mathematical tasks and structured reflection, can support these shifts. They also show that PSTs themselves can provide insight into how AI tools might better align with the goals of mathematics teaching and learning.

Looking ahead, our next steps include examining patterns across the full cohort to better understand the range of trajectories PSTs take as they learn to work with AI. We also plan to refine and extend the intervention to explore how different forms of scaffolding, collaboration, and task design influence PSTs' engagement. By continuing this work, we aim to contribute to a growing body of research that helps MTEs prepare PSTs to navigate AI thoughtfully, critically, and with a focus on meaningful student learning.

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