

Pre-service mathematics teachers' perceptions of using GenAI for practicing teacher questioning: A semester-long study

Yuling Zhuang^{1*} , Si Zhang² 

¹ Department of Teaching, Learning & Culture, Texas A&M University, College Station, TX, USA

² Center for Excellence in Teaching, Learning & Online Education, Georgia State University, Atlanta, GA, USA

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Abstract

This study investigated pre-service mathematics teachers' (PSMTs') perceptions of using generative artificial intelligence (GenAI) tools—specifically ChatGPT 4.0 and Student GPT—to support the development of teacher questioning strategies within a mathematics methods course. We examined four key areas: perceived usefulness, perceived ease of use, self-efficacy, and behavioral intention, while tracking changes in perceptions over a semester. Data sources included two written reflections, two surveys, and a final interview. Findings indicated that with increased familiarity and improved prompt-writing proficiency, PSMTs developed more positive views of GenAI integration. Perceptions were influenced by factors such as prompt writing skills, prior teaching experience, and training needs. The results highlighted the importance of sustained engagement with GenAI tools and the critical role of mathematics teacher educators in offering structured guidance and formative feedback. The practical implications for designing effective AI-integrated instructional activities were discussed.

Keywords: teacher perceptions, generative artificial intelligence, mathematics teacher education, pre-service mathematics teachers, teacher questioning strategies, ChatGPT

INTRODUCTION

Advanced generative artificial intelligence (GenAI) tools, such as ChatGPT, are transforming the educational landscape with their powerful capabilities of generating human-like text and dialogues (Zawacki-Richter et al., 2019). Studies have shown that GenAIs can provide real-time feedback, personalized learning experiences, and automated assessment, allowing teachers to shift their focus from routine tasks to higher-order instructional strategies (Lo, 2023). However, K12 teachers often lack training and support to effectively integrate GenAI into teaching practices (Gatlin, 2023; Zhai, 2024). Thus, teacher preparation programs play a crucial role in equipping future educators with the knowledge and skills to understand artificial intelligence (AI) technologies, critically evaluate their ethical implications, and strategically integrate AI into instruction (Gatlin, 2023; Hur, 2025; Tan et al., 2024; Tunjera & Chigona, 2023; United States Department of Education, Office of Educational Technology, 2023). Furthermore, a comprehensive understanding of pre-

service teachers' perceptions regarding GenAI is essential, as their attitudes and experiences significantly shape how they engage with these tools (Gatlin, 2023; Nyaaba et al., 2024; Zhuang, 2025; Zhuang & Zhang, 2024a).

This study examined pre-service mathematics teachers' (PSMTs') perceptions of using ChatGPT to support pedagogical practices, with a particular focus on teacher questioning strategies. Two AI-integrated activities were implemented in a mathematics methods course:

- (1) question generation using ChatGPT 4.0 and
- (2) simulated student-teacher interactions using a custom GPT tool (referred to as *Student GPT*).

We investigated PSMTs' perceptions of using these AI tools in supporting teaching questioning practices by examining four key areas: *perceived usefulness* (PU), *perceived ease of use* (PEU), *self-efficacy* (SE), and *behavioral intentions* (BI). Additionally, changes in PSMTs' perceptions were tracked over the semester, offering insights into the long-term impact of AI integration and

Contribution to the literature

- This study contributed to research on PSMTs' perceptions of using AI tools in supporting teaching practices in teacher preparation programs. It also examined the changes in these perceptions over a semester, offering insights into the long-term impact of AI integration.
- This study focused on leveraging AI to support mathematical pedagogy by implementing two AI-integrated activities to enhance teacher questioning practices: (1) question generation using ChatGPT 4.0 and (2) simulated student interactions using a custom GPT tool.
- The results identified key factors influencing pre-service teachers' perceptions of AI use in teacher education. Implications for effectively integrating AI into mathematics teacher education are discussed.

helping to mitigate potential bias associated with short-term interventions. This study was guided by the following research questions (RQs):

- RQ1.** What are PSMTs' perceptions of using ChatGPT 4.0 and the Student GPT in developing teacher questioning strategies?
- RQ2.** In what ways, if any, do PSMTs' perceptions (e.g., PU and PEU) change over a semester as they engage with AI tools in their instructional practices?

LITERATURE REVIEW

Teacher questioning is a foundational component of effective mathematics instruction to engage students in meaningful and productive learning experiences (National Council of Teachers of Mathematics, 2014). Research suggested that effective questioning strategies can deepen students' conceptual understanding of mathematics and enhance their reasoning, problem-solving, and critical thinking skills (Kazemi & Stipek, 2009; Martino & Maher, 1999). Mathematics teacher education programs have been focusing on teacher questioning training by introducing various questioning frameworks (e.g., assessing and advancing questions; focusing and funneling question patterns) and scaffolding the analysis and reflection of teacher question actions using classroom transcripts or video-based scenarios (Moyer & Milewicz, 2002; Smith et al., 2017). However, PSMTs often lack opportunities to practice these questioning strategies in class. PSMTs rely on questions that check prior knowledge or merely seek an answer to a problem rather than probing for deeper understanding or identifying student misconceptions (Cumhur & Güven, 2018). Mathematics teacher education programs should provide explicit training to ensure PSMTs understand diverse questioning techniques and practice reflecting on their use (Cumhur & Güven, 2018; McCarthy et al., 2016; Moyer & Milewicz, 2002). This preparation is especially important for those with limited teaching experience, who often struggle to anticipate and address students' unexpected answers or misconceptions (Didiş Kabar & Erbaş, 2021). GenAIs like ChatGPT showed the potential to address some of those challenges by offering PSMTs opportunities for guided practice, immediate feedback, and interaction with

simulated student responses. Using ChatGPT for teacher questioning training can also provide PSMTs with a personalized, low-risk, and convenient environment to practice instructional skills.

Some studies have examined PSMTs' perceptions of integrating GenAI tools into teacher preparation programs. For instance, Gurl et al. (2024) investigated how PSMTs used ChatGPT as a lesson-planning assistant in a methods course. Their findings revealed that, although some PSMTs found ChatGPT's output helpful in specific areas of content and pedagogy (e.g., assessment design), its overall PU was low. Participants reported concerns such as inaccurate mathematical content, teacher-centered lesson structures, and insufficient consideration of students' needs. Similarly, Sawyer (2024) studied how PSMTs in an elementary mathematics methods course use ChatGPT to create mathematical tasks. The results showed that while most participants viewed ChatGPT as a time-saving tool for generating lesson materials, some expressed concerns about its lack of creativity, outdated teaching methods, and potential misuse due to overreliance on AI. In addition, some studies investigated the potential of AI to enhance PSMTs' content knowledge and skills. For example, Yılmaz et al. (2025) examined PSMTs' experiences with Khanmigo, an AI tutoring system provided by Khan Academy, in elementary mathematics content courses focused on number theory. Although PSMTs found the AI was beneficial for clarifying complex concepts through multiple representations, they noted that some explanations were confusing or misleading, underscoring the need for additional verification.

As discussed above, researchers have explored the potential of integrating AI into mathematics teacher education but primarily focused on content development rather than supporting core pedagogical practices. Some researchers (e.g., Lee et al., 2024; Son et al., 2024; Zhang et al., 2024) have designed AI chatbots to support PSMTs' development of responsive teaching skills that consider students' strategies and respond to their ideas. According to those studies, PSMTs valued these AI-powered chatbots and virtual simulations as effective tools for practicing responsive teaching, refining their ability to elicit student thinking, and

gaining confidence in instruction. Nevertheless, PSMTs also criticized the authenticity of AI-generated student responses, noting that AI tools often fail to capture the complexity and unpredictability of real student thinking, which limits their effectiveness in preparing teachers for authentic classroom interactions (Zhang et al., 2024).

Although research on teachers' perceptions of AI tools is growing, research on how pre-service teachers interact with AI tools and the potential for AI integration to enhance teacher education remains limited (Celik et al., 2022; Tan et al., 2024). Most existing research relies on short-term investigations and survey-based data to examine teachers' perceptions of AI, with little attention to how these perceptions evolve through sustained engagement with AI tools over time. In addition, there is a lack of evidence on how teachers evaluate the effectiveness of AI chatbot interactions compared to conventional instructional methods, as well as on their perspectives regarding different strategies for integrating GenAI tools into pedagogical practice.

To gain a more comprehensive understanding of pre-service teachers' attitudes toward AI in teacher education, we explored PSMTs' perceptions of both non-AI-based and AI-based approaches for enhancing questioning strategies. By examining how PSMTs perceived different applications of ChatGPT in a methods course and tracing changes in these perceptions over a semester, this study aimed to provide a more comprehensive understanding of PSMTs' views of GenAI as a tool for teacher preparation and to identify factors that influence their adoption of AI tools in supporting mathematics teaching practices.

THEORETICAL PERSPECTIVE

The technology acceptance model (TAM) has been widely applied in education research to examine how users' perceptions drive the integration of innovative tools into teaching and learning (Davis, 1989). Two core constructs of TAM were used to predict users' acceptance of technology: PU and PEU. PU refers to the degree to which an individual believes technology will enhance their performance, while PEU reflects its perceived ease of learning and use (Davis, 1989). These perceptions, in turn, shape users' attitudes, influence their intention to use the technology (BI), and ultimately, their actual usage of the technology.

Researchers have used TAM to examine how PU and PEU affect learners' acceptance of AI in education (e.g., Alzoubi, 2024; Saif et al., 2024; Supriyanto et al., 2024). For example, a survey investigating Spanish K-12 teachers' acceptance of text-based chatbots revealed that positive perceptions of PU and PEU significantly contributed to a higher acceptance rate of chatbots in educational settings (Chocarro et al., 2021). Another TAM study assessed faculty members' acceptance of

ChatGPT for academic purposes at a private university in Pakistan (Iqbal et al., 2022). The findings indicated a predominance of negative PU and PEU towards ChatGPT among faculty, leading to adverse attitudes and a lack of intention to use the tool in their future classes (Iqbal et al., 2022). Additionally, an extended version of TAM was employed to explore ChatGPT's adoption among students at Omani universities for educational purposes (Tiwari et al., 2023). This study showed that while students' PU positively influenced their attitude towards using ChatGPT for learning, PEU had an insignificant effect, possibly attributed to the platform's flawed user interface causing excessive website traffic (Tiwari et al., 2023). Although TAM was used to examine faculty and students' perceptions of AI tools, the existing TAM literature lacks clarity on PSMTs' PU or PEU and how these affect them using ChatGPT to support their mathematical teaching practices.

Moreover, SE and behavior intention (BI) were also identified as critical factors regarding ChatGPT adoption (Almansour, 2024; Guo et al., 2024; Ma et al., 2025; Supriyanto et al., 2024). SE refers to the degree to which an individual believes that he or she has the ability to perform a specific task using the technology (Guo et al., 2024). For instance, Sukirman et al. (2024) reported that SE was a key factor in enhancing students' confidence in utilizing ChatGPT effectively, and BI significantly influenced its actual use. Research also showed that teachers with higher SE are more likely to apply technology in their instruction effectively (Guo et al., 2024). In this study, TAM served as a theoretical lens to guide the design of our data collection instruments and to explore PSMTs' perceptions of using ChatGPT in developing teacher questioning strategies. Specifically, we focused on four key areas drawn from TAM and related literature: PU (the extent to which ChatGPT helps improve their questioning strategies), PEU (the simplicity of operating ChatGPT), SE, the confidence of using ChatGPT in developing teacher questions), and *behavior intention* (BI, intention to use ChatGPT in developing teacher questions).

METHODOLOGY

Context and Participants

This study followed a cohort of six PSMTs enrolled in a methods course at a comprehensive state university in the United States. The research project investigated how GenAI tools could support the development of teacher questioning strategies. The methods course was designed to equip PSMTs with mathematical content knowledge and pedagogical skills for teaching mathematics at secondary-level schools. A distinctive component of this methods course was that the PSMTs were teaching in a college-level trigonometry course supervised by the methods course instructor. Each PSMT was responsible for teaching three trigonometry

Table 1. Participants' background

Participants	Gender	Race	The phase of student teaching completed
PSMT1	Male	White	None
PSMT2	Female	White	None
PSMT3	Male	White	None
PSMT4	Male	Latinx	None
PSMT5	Female	White	Phase I
PSMT6	Male	White	Phase I

Table 2. Teacher questioning activities

Week	Activity title	Description	Approach
2	Reading response assignment	PSMTs generate and revise questions based on their knowledge and/or textbook content or online resources.	Non-AI approach
6	Use ChatGPT 4.0 to generate teaching questions	PSMTs use ChatGPT to create and refine teacher questions.	ChatGPT 4.0
7	Student GPT	PSMTs interact with Student GPT to practice questioning practices.	Student GPT

sessions throughout the semester. PSMTs were encouraged to use ChatGPT to prepare their teaching practices. Specifically, PSMTs were supported to utilize AI tools during lesson preparation to support their instructional planning, particularly in developing strategic questions to elicit students' mathematical thinking and support argumentation. In addition, all PSMTs in this program must complete two phases of student teaching. Phase 1 includes semester-long class observations at local secondary schools, and phase 2 requires an entire semester of student teaching in a public secondary school. As shown in [Table 1](#), only two participants completed phase 1, and the remaining had limited or no teaching experience before enrolling on the course.

Teacher Questioning Activities

Over the semester, three major learning activities were designed to support PSMTs' development of teacher questioning strategies (see [Table 2](#)). These included one traditional, non-AI-based activity at the beginning of the semester, followed by two AI-integrated activities.

The initial activity involved a reading assignment based on chapter 1 of the textbook *building thinking classrooms in mathematics* (Lijedahl, 2020). After reading the assigned chapter, PSMTs completed the corresponding chapter activity. Specifically, they were required to create at least three teacher questions to assess and extend students' prior mathematical knowledge in teaching a particular mathematics task.

The second activity introduced a teacher questioning framework derived from the book *principles to actions* (National Council of Teachers of Mathematics, 2014) to deepen PSMTs' understanding of different question types commonly used in mathematics instruction. During class sessions, the instructor guided PSMTs in analyzing classroom teaching scenarios utilizing this framework, emphasizing the role and function of



Orange Juice Problem

Arvin and Mariah in charge of making orange juice for all students in a summer camp. They plan to make the juice by mixing water and frozen orange juice concentrate. To find the mix that tastes best, they decide to test some recipes.

Mix A 2 cups concentrate 3 cups cold water	Mix B 1 cup concentrate 4 cups cold water
Mix C 4 cups concentrate 8 cups cold water	Mix D 3 cups concentrate 5 cups cold water

Which recipe will make juice that is the most "orangey"? Explain.

Figure 1. Orange juice problem activity (Shell Centre for Mathematical Education, n.d.)

different question types. Meanwhile, the instructor introduced ChatGPT 4.0 as an instructional support tool. For their assignment, PSMTs were asked to develop five questions for each category defined in the questioning framework related to inverse trigonometric functions (for more details about instructions, see [Appendix A](#)). PSMTs were allowed to use ChatGPT 4.0 to support their question development. They were required to submit their chat history with ChatGPT along with reflective responses about their experiences (see [Appendix A](#)). These reflections included prompts to elicit their perceptions of ChatGPT, such as: "How effective do you think ChatGPT is in facilitating your development of teacher questions?" (PU).

In the third activity, PSMTs engaged with the orange juice problem (OJP), adapted from the Shell Center for Mathematics Education (see [Figure 1](#)) to practice responding to and building on students' mathematical ideas through teacher questioning. Initially, PSMTs worked in pairs to analyze student-generated solutions to the OJP, identifying common misconceptions related to ratio concepts. Subsequently, each pair developed questions to assess and advance students' understanding, which were then shared and discussed in a whole-class setting.

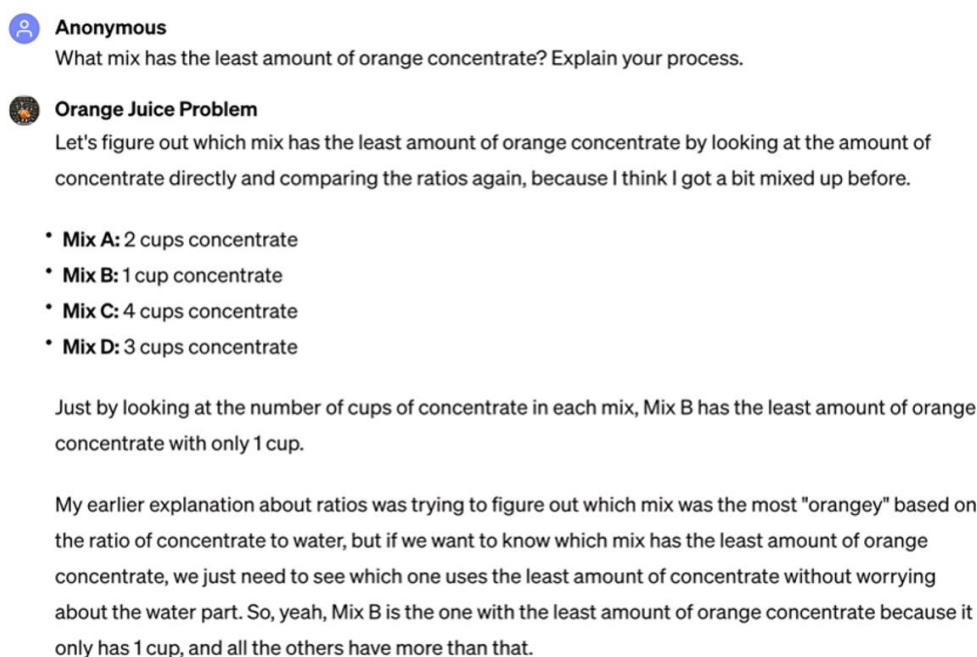


Figure 2. Example of a common misconception in ratio reasoning as demonstrated by Student GPT (Generated by the Student GPT)

For the second period of the third activity, a ChatGPT-powered customized chatbot named Student GPT was developed to simulate a middle school student, enabling PSMTs to engage in simulated teacher-student interactions. This chatbot was prompted to generate responses including at least one of the three common misconceptions related to ratio concepts based on the teacher's guide from the *orange juice problem activity* package. PSMTs interacted with Student GPT individually to address mathematical misconceptions and guide the simulated student toward correct solutions using targeted questioning strategies (for more details, see Zhuang and Zhang (2024b, under review)). **Figure 2** presents a segment from the chat history that illustrates a common misconception in ratio reasoning. In response to the PSMT's request for an explanation, the Student GPT generated a response that mixes up additive and multiplicative relationships, comparing absolute amounts rather than ratios. Student GPT also generated other types of misconceptions, such as a lack of understanding of covariational relationships and a reliance on a single problem-solving strategy.

The design of the Student GPT learning activity was inspired by practice-based theory (Grossman et al., 2009), emphasizing simulations of teaching scenarios in supportive environments with reduced complexity. This approach allowed complex teaching practices to be decomposed into manageable components. Additionally, the Student GPT activity drew from situated learning theory (Lave & Wenger, 1991), which views learning as a social process where novices progressively engage more fully within a community of practice. Thus, the Student GPT activity aimed to create authentic training environments that bridge theoretical

knowledge and practical teaching skills (Ensor, 2001), supporting PSMTs to practice questioning strategies through realistic simulated interactions.

Figure 3 presents illustrative examples of questioning strategies employed by PSMTs, including the use of accessing questions to clarify Student GPT's reasoning and advancing questions to elicit alternative solution strategies. After the activity, PSMTs submitted their chat histories along with reflective responses about their experiences using Student ChatGPT (see **Appendix A**). Similarly to the ChatGPT activity, these reflections included prompts to elicit their perceptions of the tool, such as: "How easy was it for you to understand Student GPT's responses? Justify your answer."

Data Collection and Analysis

Data for this study, including written reflections from ChatGPT 4.0 and Student GPT activities, two Likert-scale surveys conducted at the beginning and end of the semester, and a final semi-structured interview at the end of the semester, were used to examine PSMTs' perceptions of using GenAI tools within the context of a mathematics methods course. Drawing on TAM and related literature review (Almansour, 2024; Davis, 1989; Guo et al., 2024; Ma et al., 2025; Supriyanto et al., 2024), we developed written reflections, surveys, and interview questions to measure PMSTs' perceptions in terms of PU, PEU, SE, and BI. Different data sources formed a data triangulation and allowed us to further explore PSMTs' perceptions by comparing AI-based approaches with non-AI-based approaches in developing teacher questioning strategies. During the semi-structured interview, PSMTs provided ratings (on a scale from 1 to 5) comparing non-AI-based approaches,

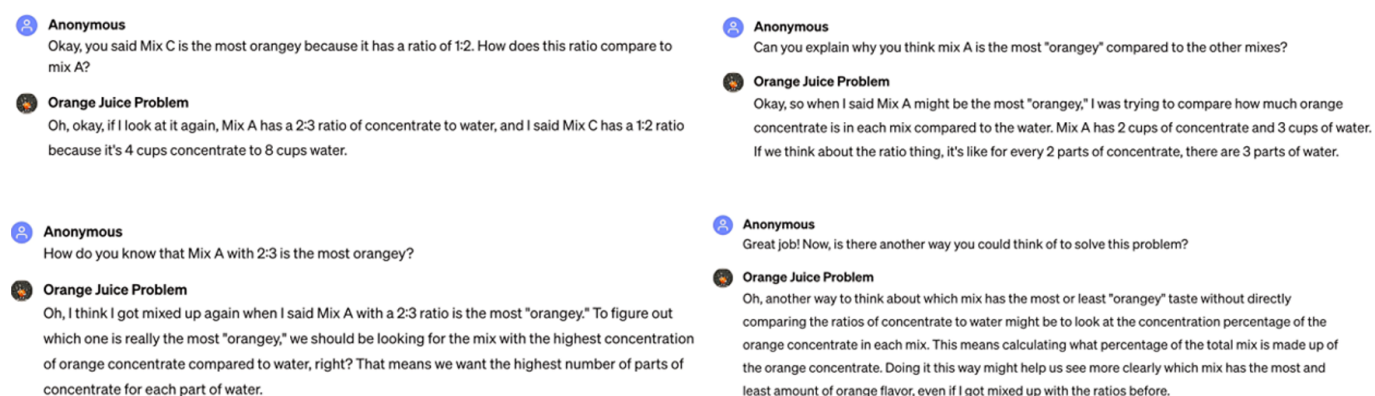


Figure 3. Chat history examples between PSMTs and Student GPT (anonymous represents different PSMTs & the screenshots only showed a small segment of the PSMT-AI conversations due to space constraints) (Generated by the Student GPT)

Table 3. Survey results on pre-service secondary mathematics teachers' perceptions of ChatGPT 4.0 and Student GPT

Component	Items	S1	S2
PU	ChatGPT 4.0 is useful for preparing me to be a mathematics teacher.	4.2	4.3
	ChatGPT 4.0 is helpful in generating teacher questions.	3.8	4
	In the orange juice problem (Student GPT), the stimulated teacher-student interactions are useful for my development teacher's questioning.	N/A	4.8
PEU	ChatGPT 4.0 has an easy-to-navigate interface.	4.2	4.5
	In the orange juice problem (Student GPT), the stimulated teacher-student interactions are easy to understand.	N/A	4.6
SE	Rate your agreement with the following statement: I can effectively use ChatGPT 4.0 to generate the expected output.	3.3	3.8
BI	How likely will you be to use ChatGPT to teach mathematics in the future?	4.7	4.7

Note. S1: Survey 1 (M) (February 2024); S2: Survey 2 (M) (April 2024); scores represent students' overall mean (M) ratings on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree); & N/A indicates that the item was not included in S1

ChatGPT 4.0, and Student GPT in terms of efficiency (PU), quality of generated questions (PU), ease of use (PEU), and desire for future use (BI) (see **Table 3** provided during the interview). PSMTs were also asked to explain the rationale behind their ratings. Additional interview questions included inquiries such as, "How helpful do you think ChatGPT is as a learning tool for improving your questioning strategies throughout the semester?" and "What factors prevented or might prevent you from using ChatGPT in teaching mathematics?" These questions aimed to gain deeper insights into PSMTs' perspectives on the effectiveness and practical application of AI-based tools in supporting mathematics teaching practices. **Appendix A** includes all written reflections and interview questions used in this study. **Appendix B** explain interview protocol.

A thematic analysis approach (Vaismoradi et al., 2013) was employed to analyze the written reflections and semi-structured interview transcripts through a structured process of coding, theme development, and interpretation. The coding process of reflections from the ChatGPT 4.0 and Student GPT activities was essentially inductive, allowing patterns to emerge from participants' language and experiences. Similarly, the interview transcripts were analyzed in an inductive approach to capture PSMTs' evaluations of the three

instructional approaches and their evolving perceptions of GenAI tools. These codes were then organized into broader thematic categories aligned with TAM constructs, such as PU and PEU, reflecting both emergent patterns and theoretical framing. Each research member independently coded the data and then discussed their codes to reach a consensus.

Descriptive statistical analyses of two Likert-scale surveys conducted at the beginning and end of the semester were used to identify changes in PSMTs' perceptions over time concerning PU, PEU, SE, and BI. Additionally, descriptive comparisons of PSMTs' ratings across AI-based and non-AI-based approaches provided further evidence of their perceptions regarding using AI approaches. Member checking and triangulation were employed to enhance the credibility and trustworthiness of the findings (Natow, 2020).

Triangulation in this study involved systematically integrating qualitative and quantitative data to strengthen the credibility and depth of our findings. For example, in the survey, PSMTs were asked to rate the PU of Student GPT. Later in the semester, during the final interviews, PSMTs were again prompted to reflect on PU, including open-ended questions, to elaborate on their perceptions. In the process of data analysis, we cross-validated themes emerging from interviews and

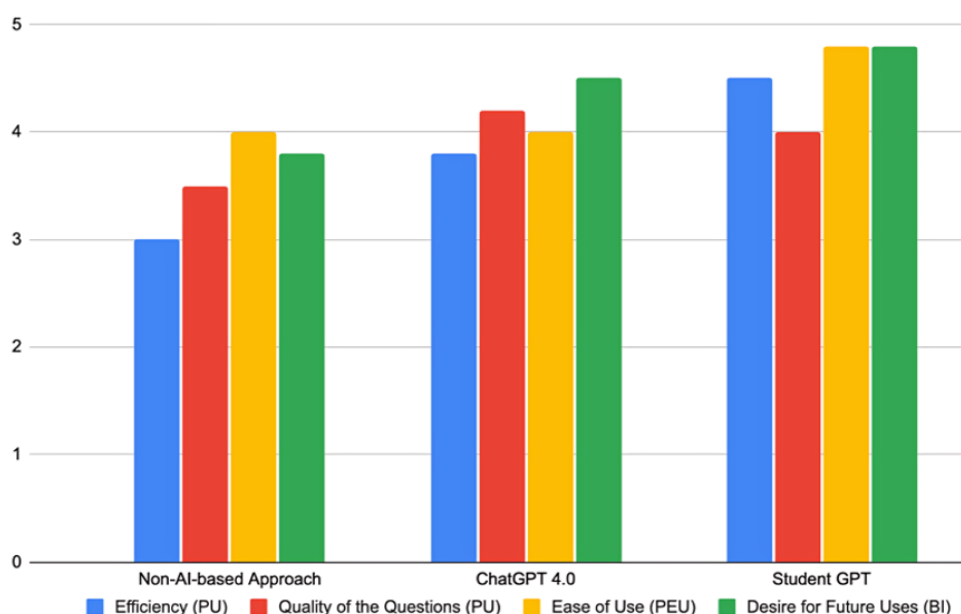


Figure 4. Mean score of student rates at the end-of-semester interview (Source: Authors' own elaboration)

written reflections with patterns identified in the survey data. To ensure a comprehensive interpretation of consistencies and changes in participants' perceptions of the tools, surveys, written reflections, and interviews were strategically conducted at different points throughout the semester, enabling us to construct a coherent and multi-faceted understanding of how PSMTs perceived and experienced the use of ChatGPT over time. Additionally, it is important to note that PSMT 6 did not participate in the Student GPT activity due to class absence. Thus, data related to his perceptions of Student GPT were excluded from the analysis.

RESULTS

Ratings for Three Approaches

As shown in **Table 3**, PSMTs' ratings were collected over the semester using a 5-point Likert scale through two surveys. The findings indicated that PSMTs perceived ChatGPT 4.0 as increasingly helpful for generating teacher questions, with mean ratings rising from 3.8 to 4.0. Notably, participants highly valued the simulated teacher-student interactions provided by Student GPT during the OJP activity, rating its usefulness for developing questioning strategies at 4.8 out of 5. They also reported a high level of ease in understanding (PEU) these simulated interactions (mean $[M] = 4.6$). In addition, PSMTs demonstrated notable growth in SE related to producing expected outputs with ChatGPT 4.0, with ratings increasing from 3.3 to 3.8. Finally, PSMTs expressed a strong and consistent BI to integrate ChatGPT into their future mathematics teaching ($M = 4.7$), highlighting their overall positive perceptions of its practical relevance and effectiveness in teacher preparation.

The mean scores of PSMTs' ratings of efficiency (PU), question quality (PU), ease of use (PEU), and desire for future use (BI) are presented in **Figure 4**, comparing AI-based approaches with non-AI-based approaches for developing teacher questioning strategies during the end-of-semester interview. PSMTs highly valued the efficiency (PU) of Student GPT ($M = 4.5$) compared to ChatGPT ($M = 3.8$) and the non-AI-based approach ($M = 3.0$). For question quality (PU), PSMTs rated ChatGPT 4.0 as generating the highest-quality questions ($M = 4.2$), followed by Student GPT ($M = 4.0$) and the non-AI-based approach ($M = 3.5$). It is important to note that the question quality for Student GPT was evaluated based on the quality of questions developed by PSMTs throughout the simulated interactions. Regarding PEU, PSMTs strongly preferred Student GPT ($M = 4.8$) over ChatGPT and the non-AI-based approach ($M = 4.0$ for each), which is consistent with the survey results. Regarding BI, the mean scores for ChatGPT 4.0 and Student GPT were 4.5 and 4.8, respectively, compared to the non-AI-based approach ($M = 3.8$). Overall, PSMTs expressed positive perceptions of AI-based approaches, rating them higher across all measured areas. These findings align with the survey data, further validating PSMTs' positive perceptions of using AI in supporting mathematical pedagogical practices.

Perceived Usefulness of ChatGPT 4.0

Analysis of PSMTs' written reflections and interviews revealed a notable shift in their perceptions of ChatGPT's PU over the semester. Early in the semester, many PSMTs described ChatGPT as merely a "*starting point*" for generating ideas, emphasizing the need for teacher verification before using any AI-generated questions in the classroom.

For instance, PSMT6 stated, *"I think that I will begin to start using it for my lesson plans... but not much more than that."* (written reflection). The analysis of PSMTs' early reflections revealed their concerns regarding the production of overly broad or inappropriate teacher questions, the necessity of human oversight, and the complexities of tailoring AI-generated content to specific instructional contexts.

In the early stages of exploration, PSMTs reported receiving questions from ChatGPT that were either too broad or misaligned with the complexity appropriate for their students.

For example, PSMT1 noted the need to be more precise in question requests, as the AI does not know *"what kind of questions I am looking for"* (written reflection). Similarly, PSMT2 underscored that although ChatGPT could generate questions, *"The students may get confused if the questions are too broad"* (written reflection). In addition, some PSMTs pointed out, *"It took a long time"* (PSMT5, written reflection) to evaluate AI-generated suggestions.

PSMTs emphasized the need for human oversight in the written reflections to address potentially confusing AI-generated questions, including approaches like fact-checking, rewording, and ensuring alignment with instructional goals. PSMT3 stated, *"It is up to us as teachers to fact-check ChatGPT,"* PSMT5 also reflected, *"It was giving me good questions, but I would have reworded them or expanded off of them."* PSMT6 echoed this view, commenting that AI-generated questions *"are good but should still be then edited by the teacher."*

PSMTs also emphasized that the PU of ChatGPT depended on how well its outputs aligned with specific instructional contexts. Several PSMTs described the AI-generated responses as disconnected from actual lesson content, highlighting *"The biggest struggle is coming up with what questions to ask at certain stages of the lesson"* (PSMT 2, written reflection). Additionally, PSMT5 noted instances of repeated questions generated in varying contexts, complaining, *"It would be faster for me to just think of questions"* (written reflection).

As the semester progressed, many PSMTs grew an appreciation of ChatGPT's capacity to generate different types of questions, facilitate mathematical connections, and support lesson planning. PSMTs reported that their continued use of ChatGPT to generate teacher questions for the trigonometry lessons proved beneficial in producing various question types, as noted in the end-of-semester interviews. For example, PSMT2 commented that ChatGPT sometimes generated a *"new type of question that I hadn't thought of,"* illustrating how the tool could expand teachers' repertoires for prompting student thinking. Additionally, PSMT1 spoke highly of ChatGPT's ability to make: *"connections in math that you can't make them yourself"* (interview). ChatGPT also assisted PSMTs in lesson planning. For

example, PSMT3 reported that he *"would go through [his] lesson plan with ChatGPT"* (interview) to obtain questions that might arise during instruction, thereby enhancing his overall preparedness and instructional planning.

Several PSMTs reported ongoing challenges related to the efficiency and quality of ChatGPT's output, highlighting the continued need for substantial teacher intervention. For example, PSMT6 believed that human-generated questions outperform those created by AI, as teachers have a deeper understanding of students' needs and classroom context. In addition, PSMT3 described the tool as a *"double-edged sword,"* noting that while it produced some useful questions, others were too advanced or unrealistic for students.

Perceived Ease of Use of ChatGPT 4.0

Initially, most PSMTs encountered challenges crafting effective prompts for ChatGPT, often resulting in broad, unclear, or redundant AI-generated responses. For instance, PSMT4 emphasized that the tool's effectiveness depended on the prompt writing skill and wrote, *"If you are not skilled in getting AI to do exactly what you want, then it won't do what you want it to do because you weren't specific enough"* (written reflection). PSMT5 shared that uncertainty in prompt writing led to repetitive outputs and a time-consuming review process, and concluded, *"I think I need more practice to ask it exactly what I am looking for"* (written reflection).

As PSMTs engaged more with AI tools, their prompt engineering skills improved, leading to more relevant and precise responses. By the end of the semester, they reported noticeable improvements in PEU during interviews. For instance, PSMT5 explained, *"Once I figured out how to better write the prompt, it was really easy to use, and it gave me a bunch [of ideas] super fast."* (interview). Similarly, PSMT4 reflected, *"The more specific I got [for the prompts], the closer the output was to what I actually wanted"* (interview). Reflecting on the tool's collaborative potential, PSMT5 praised its convenience: *"It's been really good to use and very convenient, especially if I want to bounce ideas off people. It's also easy to do that with ChatGPT if I don't have someone to talk to because it can give you good ideas really fast"* (interview).

Perceived Usefulness of Student GPT

Initially, PSMTs experienced direct benefits in Student GPT to help them practice teacher questions in a dynamic, conversational environment. In their reflections, all PSMTs described the tool as *"helpful"* for practicing teacher questioning strategies. Many appreciated how Student GPT offered insights into the effectiveness of their questions, *"It helps you see if the computer can't figure out what you are asking"* (PSMT4, written reflection). Additionally, PSMTs valued the simulation of a student's thought process: *"It is very*

helpful because it feels like a real simulation of what students might actually ask me" (PSMT3, written reflection).

By the end of the semester, PSMTs consistently identified Student GPT as one of the most valuable AI tools they used, particularly given their limited teaching experience. PSMT1 described it as *"a good way to get practice, the closest you can get to a student,"* PSMT2 called it *"the most beneficial, especially if you just don't even know where to start."* PSMTs also appreciated Student GPT's ability to generate unexpected lines of reasoning, which mirrored the unpredictability of real classroom interactions. For example, PSMT1 noted that it helped prepare for *"questions that students may have that you may not think of,"* PSMT2 added that it was helpful in learning *"how to structure different responses for questions you may not have been expecting."* These interactions encouraged deeper reflection on questioning practices, as PSMT1 remarked, *"It made you think about the questions you had to ask,"* and PSMT3 emphasized its value in helping teachers *"prepare for any questions" students might pose.*

Perceived Ease of Use of Student GPT

In their early reflections, most PSMTs found Student-GPT's step-by-step explanations of student thinking and misconceptions to be clear and easy to follow. PSMT1 noted that *"every step of its process was well explained,"* PSMT2 added that it clarified areas of confusion and highlighted students' struggles during problem-solving. However, some PSMTs pointed out the wordiness of Student GPT. PSMT4 commented that responses were sometimes *"too long"* and difficult to interpret without using precise wording. Similarly, PSMT5 observed that *"it takes a while to understand what [Student GPT] is responding with"* (written reflection).

By the end of the semester, nearly all PSMTs reported that Student GPT was easy to use. However, several also encountered specific challenges during their interactions with the tool. For instance, PSMT4 attempted to guide Student-GPT toward using a common denominator strategy to compare fractions, but the tool resisted the redirection, underscoring the challenge of reorienting the tool when the conversation did not proceed as intended. Additionally, some PSMTs found the responses overly detailed or unrealistic for typical classroom discourse. As PSMT1 noted, *"I know a student's not gonna say that to me"* (interview).

DISCUSSION AND IMPLICATIONS

This study examined PSMTs' perceptions of integrating GenAI tools into their questioning practices in a mathematics methods course. Over the semester, PSMTs used ChatGPT 4.0 to generate and refine instructional questions. An AI-based student simulation tool, the Student GPT, was also implemented to assist PSMTs in practicing and enhancing their questioning strategies in simulated classroom interactions. Overall,

PSMTs expressed positive perceptions regarding the integration of AI-based approaches to support their teacher questioning practices, as reported in their written reflections, survey responses, and interviews.

Initially, PSMTs perceived ChatGPT 4.0 primarily as a starting point for question generation, emphasizing the need for human oversight due to concerns about quality and contextual appropriateness. These initial perceptions aligned with prior research indicating that AI-generated lesson materials often require substantial revision to ensure correctness, appropriateness, and alignment with student-centered instruction (e.g., Gurl et al., 2024; Sawyer, 2024). However, through consistent exposure to ChatGPT over the semester, PSMTs began recognizing the additional benefits of the tool. They highlighted ChatGPT's ability to support mathematical connections and generate diverse questions they had not initially considered. This shift in perception was also identified in the survey results, including increased ratings in PU from the beginning to the end of the semester. While initial perceptions of ChatGPT were cautious and skeptical, PSMTs' growing familiarity with GenAI led to a deeper understanding of its potential to scaffold instructional practices. These findings suggested that mathematics teacher educators (MTEs) should provide PSMTs sufficient time and structured guidance to engage with AI tools. Gradual and guided interactions facilitate PSMTs' progression from initial awareness through active exploration toward effective integration of AI tools into their future teaching practices (Zhai, 2024).

The effective use of GenAI often demands specialized skills such as prompt engineering, which involves crafting precise inputs to guide AI systems in generating relevant and accurate outputs (Nazari & Saadi, 2024; Shanuka et al., 2024). Throughout their reflections and interviews, PSMTs stressed how limited prompt-writing proficiency initially made AI-based approaches appear time-consuming and less efficient than traditional methods. As they improved their ability to craft effective prompts, PSMTs increasingly recognized the advantages offered by AI tools. This progression was reflected in their end-of-semester interview and higher ratings of PEU and SE on the end-of-semester survey. These findings demonstrated the importance of providing PSMTs with explicit instruction and sufficient practice in formulating clear, targeted prompts to maximize the benefits of GenAI. Although approaches to prompt engineering vary, researchers have identified the need for teacher education programs to integrate prompt-writing guidance (Moorhouse et al., 2025; Park & Choo, 2024). Accordingly, MTEs must develop robust prompt engineering skills to provide PSMTs with clear guidelines, illustrative examples, and targeted support to enhance PSMTs' confidence (SE) and PEU in effectively integrating GenAI into their teaching practices. This may also require additional professional

development for MTEs and institutional support to address this emerging need and ensure that teacher educators are adequately prepared to guide AI integration in teacher preparation programs.

PSMTs highly valued Student GPT for supporting their questioning practices, as reflected in the high survey ratings and positive feedback in their written reflections and interviews. They recognized Student GPT as a beneficial practice-based training tool, particularly appreciating its capacity to simulate student thinking and provide interactive teaching experiences resembling real classroom interactions. However, our analysis indicated that teaching experiences influenced PSMTs' perceptions of Student GPT. Specifically, PSMTs 5 and 6, who had completed phase I student teaching and had relatively more teaching experience than their peers (see [Table 1](#)), preferred generating teacher questions by themselves. PSMT6 consistently critiqued AI-based approaches as time-consuming, asserting that questions developed from the teacher's experiences and professional judgment were most effective. In contrast, PSMTs with limited teaching experience preferred Student GPT, noting that it provided immediate feedback on their questioning strategies and supported them in anticipating student responses. These findings showed that novice teachers substantially benefit from the structured support and instant feedback provided by AI-based simulations. However, more experienced teachers may prefer relying on their developing pedagogical expertise to formulate instructional questions. Nevertheless, we argued that even experienced teachers can benefit from AI simulation tools like Student GPT. AI tools can simulate diverse student thinking patterns and misconceptions, enabling teachers to practice adaptive instructional approaches and critical pedagogical reflection. Therefore, MTEs should strategically adapt GenAI tools according to teachers' varying professional backgrounds and design targeted activities aligned with specific instructional needs. Moreover, although some PSMTs expressed confidence in their independently developed instructional questions, expert evaluations remain essential to ensure the quality of these questions. Ongoing feedback and guidance from MTEs are critical in scaffolding PSMTs' effective interactions with GenAI tools.

Some PSMTs experienced challenges in effectively utilizing Student GPT to address simulated student misconceptions and guide them toward correct answers. Consequently, these PSMTs expressed frustration in their written reflections and interviews, resulting in lower ratings of BI to continue using the tool. Additionally, analysis of chat histories revealed that PSMTs were primarily result-driven when engaging with the Student GPT. Once the simulated student responded correctly, PSMTs rarely explored alternative questioning strategies or continued the interactions. To

maximize the benefits of AI-based simulations, we recommend that MTEs thoughtfully design AI-integrated activities that foster productive interactions between GenAI and PSMTs and incorporate a process-oriented approach that encourages reflection and exploration of diverse instructional strategies.

In contrast to ChatGPT 4.0, which required careful prompt engineering for generating teacher questions, Student GPT allowed PSMTs to directly engage in simulated interactions with students, making it easier to implement. However, consistent with prior research on AI-based simulated role-play chatbots (e.g., Lee et al., 2024; Son et al., 2024; Zhang et al., 2024), PSMTs noted PEU limitations regarding the authenticity of Student GPT responses, including long and redundant responses, unrealistic student language, and challenges in guiding the simulated students toward specific mathematical strategies. Future research should focus on developing more advanced AI chatbots that address these issues to better support practice-based teacher education.

Finally, PSMTs' training needs also influenced their perceptions of using AI-based approaches in mathematics teacher education programs. Among the three activities implemented to support teacher questioning strategies, Student GPT received the highest ratings in efficiency, PEU, and BI because most PSMTs in this methods course have limited teaching experience. In this study, Student-GPT was integrated into a mathematics methods course to enhance pre-service PSMTs' practice-based learning by simulating interactions with real students. This approach helped address common challenges faced by teacher educators, offering PSMTs meaningful opportunities to refine their questioning strategies and instructional skills. Therefore, when integrating AI tools into teacher education programs, teacher educators should align each tool's capabilities with targeted pedagogical goals, ensuring that AI-based activities build on PSMTs' prior knowledge and teaching experiences.

FINAL REMARKS

This study explored PSMTs' perceptions of integrating GenAI tools—specifically ChatGPT 4.0 and Student GPT—into their questioning practices within a mathematics methods course. By examining two different ways of applying GenAI—ChatGPT for generating teacher questions and Student GPT for practicing interactive questioning strategies, this study provided a more nuanced and comprehensive understanding of how PSMTs perceived AI tools in teaching preparation. Findings indicated that PSMTs developed increasingly positive perceptions of GenAI when provided with sufficient time, structured guidance, and opportunities for meaningful interaction. Moreover, prompt writing skills, prior teaching

experience, and perceived training need significantly shaped PSMTs' views on integrating GenAI into instructional practice.

While the study was limited in sample size and context-specific, focusing specifically on teacher questioning, which may restrict the generalizability of findings, it provided valuable insights into the long-term influence of GenAI tools on PSMTs' evolving perceptions, an area not yet well explored in the current literature. This study offers transferable implications for similar teacher education settings, highlighting the critical role of teacher educators in providing explicit support and designing AI-integrated activities that build on pre-service teachers' prior experiences and address their developmental needs. Specifically, teacher educators should give guidance in prompt writing, support pre-service teachers in developing a foundational understanding of how to engage critically and productively with AI-integrated activities (e.g., using a process-oriented approach and adopting an open yet critical stance), and provide opportunities for reflection on teaching practices following AI interactions, accompanied by timely and constructive feedback. In addition, the results of this study showed that PSMTs in this cohort preferred the Student GPT activity over others. One reason for this preference was that Student GPT was perceived as more accessible to novice users due to its minimal prompt engineering requirements. Therefore, we recommend that when integrating AI tools into teacher preparation courses, instructors might consider introducing similar AI activities, like Student GPT activities, first to minimize the technical barriers before progressing to activities that demand more advanced prompt writing skills. Future research could explore effective ways to sequence various AI-integrated activities, scaffold the development of AI literacy among future educators, and address the unique training needs within teacher education programs. Additionally, studies involving larger and more diverse cohorts across various subject areas and institutional contexts would be beneficial to further validate and extend the findings of this study. Looking ahead, future research should examine the longitudinal impact of GenAI engagement on pre-service teachers' instructional efficacy and explore how different AI activities shape pedagogical content knowledge development.

In addition, we notice that when PMSTs interact with ChatGPT, the process of crafting, refining, and adjusting prompts is similar to the dialogic and responsive nature of teaching. This iterative interaction between PMSTs and AI closely parallels the adaptive, real-time decision-making teachers use when responding to students' thinking in the classroom. Consequently, these activities can equip pre-service teachers not only with essential technical skills in prompt engineering but also

meaningful practice in the pedagogical habits of mind crucial for high-quality instruction.

As AI rapidly evolves, people have raised concerns about the value of higher education. We argue that by supporting pre-service teachers' participation in AI-integrated activities, teacher education can offer benefits similar to professions like law, which are valued not only for specific career paths but also for developing general skills such as precision, argumentation, and adaptability. When teacher training courses emphasize skills like responsive teaching, asking thoughtful questions, and engaging in repeated interactions with AI tools, they help pre-service teachers develop thinking and communication skills that are useful beyond teaching itself. As AI becomes more common and is a part of daily life and work, individuals who can ask good questions, understand incomplete answers, and adjust their questions to fit new situations will have an advantage. From this perspective, learning to teach in such a manner can prepare people with valuable skills in professional and everyday contexts. As AI continues to play a larger role in education, findings from this study can guide the development of future teacher education programs, helping ensure that AI activities are carefully designed to support future educators and encourage reflective, high-quality teaching practices.

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REFERENCES

- Almansour, N. (2024). Investigating factors influencing EFL learners' behavioral intentions to adopt ChatGPT for language learning. *Journal of Language Teaching & Research*, 15(6), 1910-1918. <https://doi.org/10.17507/jltr.1506.16>
- Alzoubi, H. (2024). Factors affecting ChatGPT use in education employing TAM: A Jordanian universities' perspective. *International Journal of Data and Network Science*, 8(3), 1599-1606. <https://doi.org/10.5267/j.ijdns.2024.3.007>
- Celik, I., Dindar, M., Muukkonen, H., & Järvelä, S. (2022). The promises and challenges of artificial

- intelligence for teachers: A systematic review of research. *TechTrends*, 66(4), 616-630. <https://doi.org/10.1007/s11528-022-00715-y>
- Chocarro, R., Cortiñas, M., & Marcos-Matás, G. (2021). Teachers' attitudes towards chatbots in education: A technology acceptance model approach considering the effect of social language, bot proactiveness, and users' characteristics. *Educational Studies*, 49(2), 295-313. <https://doi.org/10.1080/03055698.2020.1850426>
- Cumhur, F., & Güven, B. (2018). Investigating of preservice mathematics teachers' questioning: The reflections from teaching practice course. *Journal of Computer and Education Research*, 6(12), 195-221. <https://doi.org/10.18009/jcer.432559>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340. <https://doi.org/10.2307/249008>
- Didiş Kabar, M. G., & Erbaş, A. K. (2019). Pre-service secondary mathematics teachers' anticipation and identification of students' thinking in the context of modelling problems. *International Journal of Mathematical Education in Science and Technology*, 52(2), 208-236. <https://doi.org/10.1080/0020739X.2019.1670368>
- Ensor, P. (2001). From preservice mathematics teacher education to beginning teaching: A study in recontextualizing. *Journal for Research in Mathematics Education*, 32(3), 296-320. <https://doi.org/10.2307/749829>
- Gatlin, M. (2023). Assessing preservice teachers' attitudes and perceptions of using artificial intelligence in the classroom. *Texas Educator Preparation*, 7(2), 1-8. <https://doi.org/10.59719/txep.v7i2.35>
- Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. W. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record*, 111(9), 2055-2100. <https://doi.org/10.1177/016146810911100905>
- Guo, S., Shi, L., & Zhai, X. (2024). Developing and validating an instrument for teachers' acceptance of artificial intelligence in education. *Education and Information Technologies*, 30, 13439-13461. <https://doi.org/10.1007/s10639-025-13338-6>
- Gurl, T. J., Markinson, M. P., & Artzt, A. F. (2024). Using ChatGPT as a lesson planning assistant with preservice secondary mathematics teachers. *Digital Experiences in Mathematics Education*, 11, 114-139. <https://doi.org/10.1007/s40751-024-00162-9>
- Hur, J. W. (2025). Fostering AI literacy: Overcoming concerns and nurturing confidence among preservice teachers. *Information and Learning Sciences*, 126(1/2), 56-74. <https://doi.org/10.1108/ILS-11-2023-0170>
- Iqbal, N., Ahmed, H., & Azhar, K. A. (2022). Exploring teachers' attitudes towards using ChatGPT. *Global Journal for Management and Administrative Sciences*, 3(4), 97-111. <https://doi.org/10.46568/gjmas.v3i4.163>
- Kazemi, E., & Stipek, D. (2009). Promoting conceptual thinking in four upper-elementary mathematics classrooms. *Journal of Education*, 189(1-2), 123-137. <https://doi.org/10.1177/0022057409189001-209>
- Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge University Press. <https://doi.org/10.1017/CBO9780511815355>
- Lee, D., Son, T., & Yeo, S. (2025). Impacts of interacting with an AI chatbot on preservice teachers' responsive teaching skills in math education. *Journal of Computer Assisted Learning*, 41(1), e13091. <https://doi.org/10.1111/jcal.13091>
- Lo, C. K. (2023). What is the impact of ChatGPT on education? A rapid review of the literature. *Education Sciences*, 13(4), Article 410. <https://doi.org/10.3390/educsci13040410>
- Ma, J., Wang, P., Li, B., Wang, T., Pang, X. S., & Wang, D. (2025). Exploring user adoption of ChatGPT: A technology acceptance model perspective. *International Journal of Human-Computer Interaction*, 41(2), 1431-1445. <https://doi.org/10.1080/10447318.2024.2314358>
- Martino, A. M., & Maher, C. A. (1999). Teacher questioning to promote justification and generalization in mathematics: What research practice has taught us. *The Journal of Mathematical Behavior*, 18(1), 53-78. [https://doi.org/10.1016/S0732-3123\(99\)00017-6](https://doi.org/10.1016/S0732-3123(99)00017-6)
- McCarthy, P., Sithole, A., McCarthy, P., Cho, J.-p., & Gyan, E. (2016). Teacher questioning strategies in mathematical classroom discourse: A case study of two grade eight teachers in Tennessee, USA. *Journal of Education and Practice*, 7(21), 80-89.
- Moorhouse, B. L., Ho, T. Y., Wu, C., & Wan, Y. (2025). Preservice language teachers' task-specific large language model prompting practices. *RELC Journal*. <https://doi.org/10.1177/00336882251313701>
- Moyer, P. S., & Milewicz, E. (2002). Learning to question: Categories of questioning used by preservice teachers during diagnostic mathematics interviews. *Journal of Mathematics Teacher Education*, 5, 293-315. <https://doi.org/10.1023/A:1021251912775>
- National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA.

- Natow, R. S. (2020). The use of triangulation in qualitative studies employing elite interviews. *Qualitative Research*, 20(2), 160-173. <https://doi.org/10.1177/1468794119830>
- Nazari, M., & Saadi, G. (2024). Developing effective prompts to improve communication with ChatGPT: a formula for higher education stakeholders. *Discover Education*, 3(1), Article 45. <https://doi.org/10.1007/s44217-024-00122-w>
- Nyaaba, M., Shi, L., Nabang, M., Zhai, X., Kyeremeh, P., Ayoberd, S. A., & Akanzire, B. N. (2024). Generative AI as a learning buddy and teaching assistant: Preservice teachers' uses and attitudes. *arXiv*. <https://doi.org/10.48550/arXiv.2407.11983>
- Park, J., & Choo, S. (2024). Generative AI prompt engineering for educators: Practical strategies. *Journal of Special Education Technology*, 40(3), 411-417. <https://doi.org/10.1177/01626434241298954>
- Saif, N., Khan, S. U., Shaheen, I., ALotaibi, F. A., Alnfai, M. M., & Arif, M. (2024). Chat-GPT; validating technology acceptance model (TAM) in education sector via ubiquitous learning mechanism. *Computers in Human Behavior*, 154, Article 108097. <https://doi.org/10.1016/j.chb.2023.108097>
- Sawyer, A. G. (2024). Artificial intelligence chatbot as a mathematics curriculum developer: Discovering preservice teachers' overconfidence in ChatGPT. *International Journal on Responsibility*, 7(1), Article 1. <https://doi.org/10.62365/2576-0955.1106>
- Shanuka, K. A. A., Wijayanayake, J., & Vidanage, K. (2024). Systematic literature review on analyzing the impact of prompt engineering on efficiency, code quality, and security in crud application development. *Journal of Desk Research Review and Analysis*, 2, 235-249. <https://doi.org/10.4038/jdrra.v2i1.57>
- Shell Centre for Mathematical Education. (n.d.). <https://www.mathshell.org/>
- Smith, M., Steele, M. D., & Raith, M. L. (2017). *Taking action: Implementing the effective mathematics teaching practices in grades 6-8*. National Council of Teachers of Mathematics.
- Son, T., Yeo, S., & Lee, D. (2024). Exploring elementary preservice teachers' responsive teaching in mathematics through an artificial intelligence-based chatbot. *Teaching and Teacher Education*, 146, Article 104640. <https://doi.org/10.1016/j.tate.2024.104640>
- Sukirman, N., Supriyanto, E., Setiawan, A., Chamsudin, A., Yuliana, I., & Wantoro, J. (2024). Exploring student perceptions and acceptance of CHATGPT in enhanced AI-Assisted Learning. *International Conference on Smart Computing, IoT and Machine Learning, SIML 2024*. <https://doi.org/10.1109/siml61815.2024.10578145>
- Supriyanto, E., Setiawan, A., Chamsudin, A., Yuliana, I., & Wantoro, J. (2024). Exploring student perceptions and acceptance of ChatGPT in enhanced AI-assisted learning. In *Proceedings of the 2024 International Conference on Smart Computing, IoT and Machine Learning* (pp. 291-296). IEEE. <https://doi.org/10.1109/SIML61815.2024.10578145>
- Tan, X., Cheng, G., & Ling, M. H. (2024). Artificial intelligence in teaching and teacher professional development: A systematic review. *Computers and Education: Artificial Intelligence*, 8, Article 100355. <https://doi.org/10.1016/j.caeai.2024.100355>
- Tiwari, C. K., Bhat, M. A., Khan, S. T., Subramaniam, R., & Khan, M. A. I. (2023). What drives students toward ChatGPT? An investigation of the factors influencing adoption and usage of ChatGPT. *Interactive Technology and Smart Education*, 21(3), 333-355. <https://doi.org/10.1108/itse-04-2023-0061>
- Tunjera, N., & Chigona, A. (2023). Investigating effective ways to use artificial intelligence in teacher education. In *Proceedings of the European Conference on E-Learning* (pp. 331-340). <https://doi.org/10.34190/ecel.22.1.1625>
- United States Department of Education, Office of Educational Technology (2023). *Artificial Intelligence and Future of Teaching and Learning: Insights and Recommendations*. United States Department of Education, Office of Educational Technology.
- Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & health sciences*, 15(3), 398-405. <https://doi.org/10.1111/nhs.12048>
- Yılmaz, Z., Galanti, T. M., Naresh, N., & Kanbir, S. Exploring the interactions among instructor, prospective teachers and AI in facilitating mathematics learning. *School Science and Mathematics*. <https://doi.org/10.1111/ssm.18341>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education-Where are the educators? *International Journal of Educational Technology in Higher Education*, 16, Article 39. <https://doi.org/10.1186/s41239-019-0171-0>
- Zhai, X. (2024). Transforming teachers' roles and agencies in the era of generative AI: Perceptions, acceptance, knowledge, and practices. *Journal of Science Education and Technology*. <https://doi.org/10.1007/s10956-024-10174-0>
- Zhang, N., Ke, F., Dai, C. P., Southerland, S. A., & Yuan, X. (2024). Seeking to support preservice teachers'

- responsive teaching: Leveraging artificial intelligence-supported virtual simulation. *British Journal of Educational Technology*, 56(3), 1148-1169. <https://doi.org/10.1111/bjet.13522>
- Zhuang, Y. (2025). Lessons from using ChatGPT in calculus: Insights from two contrasting cases. *Journal of Formative Design in Learning*, 9, 25-35. <https://doi.org/10.1007/s41686-025-00098-2>
- Zhuang, Y & Zhang, S (2024a). Exploring student engagement with ChatGPT in calculus learning: a case study on contrasting perceptions. In K. W. Kosko, J. Caniglia, S. A. Courtney, M. Zolfaghari, & G. A. Morris (Eds.), *Proceedings of the forty-sixth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 1714-1719). Kent State University. <https://doi.org/10.51272/pmena.46.2024>
- Zhuang, Y. & Zhang, S. (2024b). Integrating AI in method course: Customizing ChatGPT to simulate student responses. *Association of Mathematics Teacher Educators (AMTE)'s Connections*, 34(2). <https://amte.net/connections/2024/12/integrating-ai-method-course-customizing-chatgpt-simulate-student-responses>
- Zhuang, Y., & Zhang, S. (under review). Integrating ChatGPT in mathematics teacher education: AI-based simulation role-playing to support practice-based teaching. Manuscript submitted for publication to the *International Journal of Artificial Intelligence in Education*.

APPENDIX A

Use ChatGPT to Generate Teacher Questioning

1. You will use ChatGPT to assist in the completion of this assignment. Remember that you have to switch to the GPT Team profile to be able to use ChatGPT 4.0.
2. Your task is to create a series of questions aimed at teaching **inverse trigonometric functions**. You will develop 5 questions for each of the following categories: gathering information, probing thinking, making the mathematics visible, encouraging reflection, and justification. Please state the specific math task that is associated with each question. A task can be associated with multiple questions. Utilize ChatGPT 4.0 to assist in generating these questions and consider the best way to phrase your prompts to achieve the desired outcomes.
3. Share the link to your chat history with ChatGPT.
4. Fill out the table below to list your teacher questions and the rationale for classification.
5. Write one paragraph to reflect on your engagement with ChatGPT and your experience of developing teacher questions.

Written Reflection for Using ChatGPT 4.0

Table A1. Written reflection for using ChatGPT 4.0

Reflection questions	Your responses
How effective do you think ChatGPT is in facilitating your development of teacher questions?	
What additional support or functions do you expect from ChatGPT in your development of teacher questions?	
What are your takeaways from your engagement with ChatGPT for this assignment?	

Written Reflection for Using Student GPT

Table A2. Written reflection for using Student GPT

Reflection questions	Your responses
How useful do you think this Student GPT is in helping you develop teacher questions based on students' misconceptions? Justify your answer.	
How easy do you understand this Student GPT's responses? Justify your answer.	
What are the major challenges when you engage in this Student GPT?	

APPENDIX B

Interview Questions

- In the OJP, we adopted a stimulated Student GPT. What are the benefits and constraints of that GPT based on your experience? Could you provide me with specific examples?
- In this course, we experienced three approaches to developing teacher questions, the first approach is traditional (from a textbook or self-development) without AI, the second approach is ChatGPT 4.0, and also the Student GPT from the OJP. Please rate each approach according to your experience. 5 is the most positive and 1 is the most negative.

Table B1. Rate table

Methods	Efficiency	Quality of the questions	Ease of use	Desire for future uses
Traditional				
ChatGPT4.0				
Student GPT				

- Follow-up: Could you explain why you rate in such a way?
- What is your opinion on the quality of questions? What is your definition of a high-quality question?
- Suggestions for improvement: Based on your experience, what improvements or features would you suggest for enhancing ChatGPT's utility in supporting PSMTs in developing scaffolding questions?
- What is your overall experience with using ChatGPT in terms of usability and convenience? (examples)
(What are the factors that prevented you or will prevent you from using ChatGPT in teaching mathematics?)
Follow up: Were there any challenges you faced while using this tool?
- Can you describe your initial impressions of using ChatGPT to generate questions for classroom discourse in mathematics? What were your expectations?
 - Follow up: After using GPT in this course, do you feel your expectations have changed for future uses?
 - If yes, could you elaborate on that?
- How helpful do you think ChatGPT is as a learning tool to improve your questioning skills throughout the semester?

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