More confidence more critical: Investigating secondary mathematics preservice teachers' use of an Artificial Intelligence chatbot as a curriculum development tool

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ABSTRACT

The manuscript shares findings from a study engaging secondary mathematics preservice teachers using Artificial Intelligence (AI) chatbots to design mathematics lesson plans. Phenomenology was employed to investigate how six secondary preservice teachers used AI chatbots and navigated this new resource compared to their knowledge and experience in developing culturally responsive mathematics lesson plans that included mathematics and social justice goals. Our data analysis revealed that PSTs' confidence in their Mathematical Content Knowledge and Pedagogical Content Knowledge allowed them to be critical of using AI-generated lesson plans. This finding contrasted with previous research on elementary education preservice teachers who gave away their decision-making agency to AI chatbots, especially about mathematics. The data suggests that the secondary PSTs had confidence in their Mathematical and Pedagogical Content Knowledge, making them more critical of the AI-generated lesson plans. The findings also indicate that AI tools can help teachers learn about Technological Pedagogical Knowledge (TPK). Overall, the data stressed the need to support PSTs in using AI chatbots critically. The implications of this study provide possible ways to help PSTs overcome their overconfidence in AI chatbots and imply that more professional development tools and programs must be constructed to help inservice teachers use AI tools.

Keywords: *Artificial intelligence, Artifical intelligence chatbots, Mathematics education curriculum, Mathematics teacher education, Mathematical content knowledge, pedagogical content knowledge, Technological pedagogical knowledge.*

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Highlights of this paper

- The paper highlights that secondary PSTs confidence in their Mathematical and Pedagogical Content Knowledge could make them more critical of AI-generated lesson plans.
- The paper also indicates that AI tools can help teachers learn about Technological Pedagogical Knowledge.
- The study provides possible ways to help PSTs overcome their overconfidence in AI chatbots and implies that more professional development tools and programs must be constructed to help teachers use AI tools.

1. INTRODUCTION

Today's teachers have more access to technology tools to support the development of lesson plans than ever before. Artificial Intelligence (AI) tools like Bard, Chat Generative Pre-trained Transformer (ChatGPT), and Khan Academy AI can be used to create lesson plans with simple prompts. However, these technology tools have been known to be mathematically inaccurate (Sawyer & Aga, 2024), biased toward individuals (Wu, 2023) and create inappropriate responses for students (Sawyer, 2024). AI position statements issued by the U.S. Department of education (2023) and the National Council of Teachers of Mathematics (NCTM) (2024) stress that teachers must be cautious when using AI tools in education classrooms. Findings from research about the use of AI tools for elementary curriculum development show that pre-service teachers (PSTs) tend to have overconfidence in the abilities of AI tools to construct lesson plans (Sawyer, 2024).

This research investigated how secondary PSTs used AI tools to develop lesson plans. Research is needed to explore the effective use of AI tools in educational contexts (National Council of Teachers of Mathematics (NCTM), 2024; U.S. Department of education, 2023). It is crucial to support PSTs' learning about pedagogies that aid the development of students' mathematics knowledge and building positive mathematical identities (Aguirre, Mayfield-Ingram, & Martin, 2024). Mathematics Teacher Educators (MTEs) must understand AI tools related to culturally responsive mathematics. This manuscript provides the needed research to determine how PSTs use AI tools, specifically when considering Culturally Responsive Mathematics Teaching (Aguirre & del Rosario Zavala, 2013).

Existing mathematics education courses focus on developing PSTs' mathematical and pedagogical content knowledge (Aguirre et al., 2017). While this knowledge is necessary to prepare the PSTs, focusing on equity-based teaching practices can communicate its value to PSTs (Aguirre et al., 2017; Bartell & Aguirre, 2019). There needs to be a balance between instruction focusing on mathematics and instruction built on students' knowledge and lived experiences (Civil & Khan, 2001; González, Adrade, Civil, & Moll, 2005; Norma González, Andrade, Civil, & Moll, 2001). According to Aguirre and del Rosario Zavala (2013) developing culturally responsive mathematics teachers (CRMT) requires changing their perception of teaching to create engaged citizens who are critical members of society. Engaging PSTs in developing lesson plans guided by the CRMT guidelines can help them develop this perception and learn how to create mathematically rigorous lessons, build on students' funds of knowledge, and be sensitive to social justice issues (Aga, 2024).

Six PSTs enrolled in a secondary mathematics methods course engaged in the investigation and used AI tools to develop culturally responsive lesson plans. Our specific research question was: *How do secondary mathematics PSTs engage with AI to generate culturally responsive mathematics lesson plans?*

2. LITERATURE REVIEW

Despite a common perception that AI is a new phenomenon, it has existed since the 1950s (Turing, 1950). However, AI tools like chatbots or large language models (LLMs) have only recently helped answer teachers' questions about their classrooms in a user-friendly capacity. For example, teachers can ask questions like "Create a

lesson plan, focusing on conceptual understanding around ratio and proportions," and an AI chatbot can create lesson plans with activities that can be implemented in the classroom. While this is a convenient resource, literature shows that AI tools are not consistently mathematically accurate, can create bias (Wu, 2023) and need more human discretion when constructing responses (Sawyer & Aga, 2024; Wu, 2023). For example, many LLMs struggle with mathematical concepts like multiplication (Sawyer & Aga, 2024). This is problematic for MTEs because they do not want PSTs to unthinkingly follow these computer responses without using their discretion (National Council of Teachers of Mathematics (NCTM), 2024).

Given the potential of AI to aid teachers in curriculum development, teacher education programs need to find ways to guide PSTs in using it with a critical lens to help build discretion. When used correctly, AI can serve as a tool to develop creative educational opportunities for students that challenge and foster their creativity (Kayabas, 2024; Tariq, 2024). In addition, AI can help create learning opportunities that meet students' individual needs (Su & Zhong, 2022; Tariq, 2024). In addition, AI tools can aid in differentiating instruction guided by students' assessments to design learning plans that meet the specific needs of students (Somasundaram, Latha, & Pandian, 2020). Research also suggests that AI-supported instruction can help meet students' diverse learning needs by identifying learning gaps earlier on so teachers can provide learning support in a timely manner (Raza, 2023; Walter, 2024).

While AI has potential benefits, its use for developing educational curricula has also raised ethical concerns. Caution is warranted when using AI in education to ensure the safety of all participants, especially students (Chaudhry & Kazim, 2022). A crucial problem is regarding data use and privacy. For example, if student data is used to design instructional plans, it becomes critical to put safety measures in place (Božić, 2023; Tapalova & Zhiyenbayeva, 2022). In addition to safety measures regarding data, there is a need to develop policies about the ethical use of AI in education (Huang, 2023).

Most importantly, educational personnel need guidance and training regarding AI's ethical and critical use (Seaba, 2022). Preservice and inservice teachers must learn effective and safe ways to use AI as an educational resource. With guidance, teachers can use AI tools to improve their students' learning experience (Ejjami, 2024; Hamal, El Faddouli, Harouni, & Lu, 2022).

Regarding teacher preparation, Sawyer (2024) investigated elementary PSTs' use of AI chatbots to create lesson plans to determine the PSTs' perceptions and how they would adapt their resources. Despite trying to teach criticality, Sawyer (2024) found that the majority of the elementary PSTs submitted curriculum materials to implement in an elementary classroom that were almost identical to the responses given by ChatGPT. The study identified that the PSTs understood that they should be cautious, yet they did not heed the warning; instead, they trusted the technology to create effective pedagogy around mathematics. The investigation described in this manuscript is a follow-up study to Sawyer (2024) investigation into elementary mathematics PSTs. Our goal was to determine if a lack of criticality also occurred among secondary mathematics education students.

3. THEORETICAL FRAMEWORK

Culturally Responsive Mathematics Teaching (CRMT) includes knowledge, beliefs, and teaching practices that highlight mathematical thinking, culture, language, and social justice issues (Aguirre, 2009; Aguirre & del Rosario Zavala, 2013; Gay, 2009; Gutiérrez, 2009; Kitchen, 2005; Leonard, Brooks, Barnes-Johnson, & Berry III, 2010; Turner et al., 2012). It includes eight dimensions based on pedagogical content knowledge (PCK) and culturally responsive pedagogy (CRP) (Ladson-Billings, 1995) that provide guidelines for equitable mathematics teaching. The first five dimensions focus on Mathematical Thinking: 1) intellectual support, 2) depth of student knowledge and understanding, 3) mathematical analysis, 4) mathematical discourse, and 5) communication and student engagement.

Dimension six has two subcategories that both focus on students' language: 6a) academic language support for English language learners (ELL) and 6b) use of English as a second language (ESL) scaffolding strategies. Dimension seven stresses the use of mathematical knowledge and practices from students' households and communities (Civil, 2007, 2016; Civil & Khan, 2001; Díez-Palomar, Simic-Muller, & Varley, 2007; Moll & González, 2004; Perkins & Flores, 2002; Staats, 2009; Turner et al., 2012; Turner, Gutiérrez, Simic-Muller, & Díez-Palomar, 2009). Here, the authenticity of the context of the problem plays an important role. The eighth dimension focuses on using critical knowledge and social justice in lesson plans. The goal is for students to use mathematics as an analytical tool for solving problems and taking actionable steps toward social justice issues.

Pedagogical Content Knowledge is the intersection between Pedagogical Knowledge (PK) and Content Knowledge (CK), which comes from Shulman (1987). Pedagogical Content Knowledge (PCK) "distinguishes the understanding of the content specialist from that of the pedagogue" (Shulman, 1987). Teachers have a domain of Content Knowledge that emphasizes the elements of the subject matter, such as scientific laws or math-proof construction. Teachers' general understanding of techniques in terms of classroom knowledge is where they use their Pedagogical Knowledge, for instance, knowing how to manage small groups. Teachers think about the pedagogical strategies specific to their content area of expertise, and the interaction of both is thinking within Pedagogical Content Knowledge. For example, thinking about how to have students understand the visual explanation for completing the square through modeling.

Mishra and Koehler extended the PCK framework to integrate Technology Knowledge (TK) (Celik, 2023). Technology Knowledge examines what the person knows about the features and characteristics of the technology. This alignment led to the generation of Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK). Technology Knowledge interacts with both Pedagogical Knowledge and Content Knowledge. Technological Content Knowledge refers to teachers' knowledge of how technology has affected their field, where teachers may understand how different software applies to their knowledge—for instance, the functions of Excel and how they relate to mathematical procedures. TPK considers the interaction of technology with the way teachers deliver and teach (Koehler & Mishra, 2009). How would teachers consider using a YouTube video in the classroom to lead the discussion, and how may it lead to distractions or if that link does not work? Alternatively, the knowledge of which technology is best used to debate or how to alter the features of technology for eliciting student thinking, the teacher moves around technology. The interaction between Content Knowledge, Technology Knowledge, and Pedagogical Knowledge is known as Technology Pedagogical Content Knowledge (TPACK).

4. METHODOLOGY

The study employed Phenomenology to identify PSTs' perceptions about using AI as a tool to generate mathematics lesson plans (Moran, 2000). Phenomenology guided the analysis of how PSTs view AI as a tool and use it to develop lesson plans.

The study took place in a secondary mathematics methods course at a mid-sized university in the Mid-Atlantic region of the United States. The course was geared towards mathematics pedagogy and specially focused on CRMT and teaching mathematics for social justice (TMSJ). In their previous course with the same mathematics teacher educator (MTE) (first author), the PSTs read literature on CRMT and TMSJ (Aguirre, Zavala, & Katanyoutanant, 2012; Chval & Chávez, 2011; Koestler, 2012). These readings introduced the PSTs to ideas of inclusive teaching practices in mathematics that allow for the development of students' mathematics identity. The PSTs discussed these pedagogies and shared their concerns about implementing them in actual classrooms. PSTs studied examples of lesson plans that included mathematics and social justice goals. The PSTs engaged in several iterations of developing and

revising culturally responsive lesson plans that included mathematics and social justice goals. This experience allowed them to create lesson plans based on CRMT and TMSJ.

In the current course, the PSTs were asked to draw on their previous experience and develop CRMT lesson plans that included mathematics and social justice goals. This time, they were asked to employ an AI chatbot to aid their design process. PSTs were asked to include at least one social justice standard (Learning for Justice, 2022) as a social justice goal. PSTs were also required to include support for emergent multilingual learners (EMLs) in their lesson plans.

4.1. Participants

The participants comprised five female and one male PSTs in a secondary mathematics methods course taught in Fall 2023. All six students were in their senior year at the university, working on their bachelor's degree in Mathematics. Each participant was also working on a minor in secondary education and planned to apply to graduate school to receive their Master of Arts in Teaching at the same institution as their bachelor's degree.

4.2. Data Collection

PSTs were asked to develop a Culturally Responsive Mathematics lesson using mathematics and social justice goals for a high school classroom. PSTs used Google Bard (now Gemini) to generate several lesson plans, including a final version based on their experience with AI-generated lesson plans. The PSTs submitted their AI-generated lesson plan and final lesson plan, including assessments, worksheets, PowerPoint, and reflections on their experience. The PSTs also implemented the lesson in their class with their peers as students.

The reflection on the experience asked them to share the prompts they used to generate the AI lesson plan, critique the AI-generated lesson plan, develop their lesson plan, and share how their plan is similar or different to the AI-generated lesson plan. PSTs also provided peer feedback on other students' lesson plans and incorporated it into their lessons. PSTs were asked to answer the following question in their final reflection:

1. *What was your mathematics standard, and why did you select it?*
2. *What were your social justice standards, and why did you choose them?*
3. *What was your learning goal (including both mathematics and social justice)?*
4. *How will you assess that you have reached your learning goal?*
5. *Describe your process of developing an AI-generated lesson plan.*
6. *Provide each prompt you used to get to the AI-generated lesson plan and share what was missing in each iteration of the lesson plan that caused you to use a different prompt.*
7. *Use 2-3 paragraphs to describe your critique of the AI-generated lesson plan (what you would keep and change).*
8. *Use 2-3 paragraphs to explain how your final lesson plan is similar to or different from the AI-generated lesson plan.*
9. *As a teacher, how confident do you feel using AI-generated lesson plans?*

4.3. Data Analysis

The data included prompts to generate AI lesson plans, final lesson plans, and reflections. The data obtained were coded and analyzed for themes using thematic analysis (Gibbs, 2007). The thematic analysis found themes from the participants' experiences (Celik, 2023) by coding for Content Knowledge (CK), Pedagogical Content Knowledge (PCK), and Technology Knowledge (TK) as described above in the manuscript. The analysis involved reviewing the AI-generated lesson plans and the final lesson plans multiple times to get acquainted with major patterns, meanings,

and discrepancies. Major themes were constructed from the data around the PSTs' perceptions of using AI chatbots for lesson planning.

5. FINDINGS

Data analysis revealed that PSTs mostly used CK and PCK to critique the lesson plans. There were also some instances of PSTs using TK, but only a few. When critiquing the lesson plans, the PSTs shared that while the AI-generated lesson plans were organized well, they lacked in many pedagogical aspects. In this section, the main themes from our data analysis are shared.

5.1. PSTs Positioned Themselves as Experts When Critiquing the AI-Generated Lesson Plans

The activity allowed PSTs to learn about the limitations of AI. PSTs' reflection on their experience using AI indicated that the AI-generated lesson plans were "too general and vague" in the sense that the lesson plan would provide instructions such as "present students with a set of word problems…" or "distribute circle worksheets to each group," the AI tools did not provide details of these activities or any supporting instructional material. This output from the AI chatbot was surprising for the PSTs. In their own words, "I would have thought that Bard would include these materials linked, but they were not." The PST was expecting a more comprehensive lesson plan from AI but was disappointed.

PSTs recognized that they have to improve the instructions they provide to the AI. For example, one PST tried six different prompts and analyzed six resulting lesson plans. This investigation enabled the PST to learn about improving their prompts because they wanted an AI chatbot to generate specific results. The PST explained their process,

"The first 4 prompts and drafts included a review on the circle equation, circumference formula, area formula, features of circles, discovering pi, and discovering the similarity of circles. I was realizing that this was going to be way too much information for one lesson, especially if I wanted the main idea of the lesson to be about the similarity of circles, along with the similarity of people."

The PST realized that the AI chatbot would continue to produce vague lesson plans unless the PST changed the prompt. The PST wanted students to do a hands-on activity and discover the similarity of circles, so in prompts 3 through 6, they added the following phrase, "include a hands-on activity when discovering the similarity of circles." The process of generating lesson plans allowed the PST to learn about using specific prompts, reflect on their own learning goal and how to make their lesson plan more specific to their learning goal. The PST decided to add components from these iterations to their final lesson plan and became critical of their own planning regarding what to focus on. In the PST's own words, "My prompts began changing and becoming more specific as I was remembering what is important to discovering the similarity in circles." The PST stopped including the full math standard in the prompt because that provided a broad output by the AI tool. They started including content-specific statements to make their prompt specific. By the end of the process, the PST realized that the AI chatbot was not the magic tool they hoped it would be. The PST shared, "I was hoping that an *AI-generated lesson plan* meant that activities, notes sheets, worksheets, and the full lesson plan would all be instantly created from scratch by Bard. I was wrong in thinking this." For this PST, their knowledge of mathematics and pedagogy allowed them to critique AI-generated instructional material. This experience is representative of all six PSTs. PSTs' existing knowledge allowed them to be the authority in making decisions when critiquing AI-generated lesson plans and designing accompanying instructional material.

5.2. PSTs used CK and PCK to assess AI-Generated Lesson Plans

The knowledge that allowed PSTs to critique AI-generated lesson plans was mostly CK and PCK. One PST compared two versions of AI-generated lesson plans and shared,

"They both outlined the learning objectives that the procedure reflects. There are clear and explicit moments in the procedure where students can identify the converse, inverse, and contrapositive of a conditional statement, translate a short verbal argument into symbolic form, and determine the validity of a logical argument. There are little details that are different, but the general idea is the same. I would keep the examples because they are simple examples that are easy to understand."

Here, the PST decided that the lesson plans were sufficient and they would keep the examples in the AI-generated lesson plan. This PST needed an understanding of the content being taught to decide what components of the AI-generated lesson plan to keep. Another PST critiqued the AI-generated lesson plan by stating,

"Intro discussion on slope heavily covers graphical representation of slope but doesn't cover the slope formula specifically for finding the slope between two points nor does the discussion specifically talk about where slope is located in the slope intercept form equation. The discussion does cover rise over run which would allow students to count out the slope between two points without knowing the formula, but only if those points are reasonably close to one another and the student had a way to graph them. The same is true for the equation, if students had a way to graph the equation then they could find the slope graphically by starting with the equation."

This PST understood how their students would best learn the content and what concepts to focus on to aid their students' learning. The PST's existing knowledge of CK and PCK helped them analyze components of AI-generated lesson plans.

5.3. PSTs Found AI-Generated Lesson Plans to be Generic and Vague

PSTs noticed that the AI-generated lesson plans needed to be more detailed. One PST commented, "Overall, all of the AI-generated lesson plans were very generalized and vague. In the case where you would have to leave plans for someone else to reference, I don't think that they are specific enough." Here, the PST refers to another teacher using the lesson plan and possibly having difficulty making sense of it because it lacks detailed instructions. Another PST shared that their lesson plans are, in general, more detailed than what the AI-generated,

"When I first looked at the AI plans, I had a hard time even knowing what was going on; it is unclear what is actually happening and what materials students/teachers are using. Thus, a difference between my plan and the AI plan is that my plan has notes, activities, and worksheets that may be readily implemented."

Another PST shared this sentiment, "The AI plan provided a good base to go off of, but it is very vague, so I would change it by adding more details so that it is a more thought through lesson plan." These comments point towards PSTs' critical use of AI-generated lesson plans.

In addition to the lesson plans needing to be more specific, the PSTs noted that the context provided by AI was not always a good fit for the students for whom the lesson plans were made. One PST explained, "The social justice standards that were given through the AI were also very generalized and did not connect with students on a more personal level because it dealt with more global issues, and high schoolers are often more in touch with their community issues." PSTs could gauge if an AI-suggested context would be appropriate for high school students. The PSTs had already been inside middle and high school classrooms as part of their field experience, and their experience helped them gauge if a specific context would work in an actual classroom. The PSTs could compare the quality of their own lesson plans versus the ones generated by AI chatbots and position themselves as more knowledgeable when generating mathematics lesson plans.

5.4. PSTs Found the Assessments Included in AI-Generated Lesson Plans to be Insufficient

Many PSTs shared that AI-generated lesson plans used inefficient instructional strategies when assessing student learning, as can be gleaned from this comment.

"The summative assessments come from class discussions which are all over the place in this lesson. It is not explicitly stated in the lesson plan, but I would have students discuss the social justice tie-in in small groups rather than as a class so that students feel more comfortable and so that there is more of a chance for every student to speak in order for me to observe them."

Here, the PST was concerned about their students feeling comfortable enough to share their thinking in the classroom. All PSTs were concerned about their students, as can be gleaned from this comment.

"The AI created summative assessments more often than formative assessments, which I would not do in a lesson that students are seeing for the first time. In version one, students learn about multistep linear equations with one variable and then are quizzed on the topic later in that same class period. This does not seem like sufficient time to master multistep linear equations, so I would omit this part if I were to adopt this lesson plan."

For this PST, it was a simple matter of realizing that it would take longer for students to learn the content than the time included in the lesson plan. Another PST noticed the same occurrence in their AI-generated lesson plan and stated, "I think this does align with the learning objectives, but it might be too early to do a quiz when they just learned it for the first time." These were seemingly minor errors, but the fact that PSTs had a chance to catch them allowed them to become mindful of AI-generated instructional material and the changes required to make them well-suited for classroom use.

5.5. PSTs used AI-Generated Lesson Plans as A Resource

What PSTs chose to keep and change in the AI-generated lessons shows their prowess in developing mathematics lessons. They used PCK (28 instances), CK and PK (9 instances), and TK (1 instance) in this process. PSTs used the AI-generated lesson plans in two ways: (1) keeping components of the various AI lessons and incorporating them into their lesson plans, and (2) reorganizing the AI-generated lesson plans and developing their own material to supplement what AI produced.

In the first case, the PSTs decided to go with their lesson plan and use AI-generated instructional material such as worksheets, discussion prompts, or tasks from various lesson plans. A PST explained this approach.

"From the AI generated plans, I plan to keep different parts from each of them. I really liked the introduction activity, activity 2, activity 3, and the exit ticket from prompt 3. From prompt 2, I liked activity 3 and the extension activity. I felt like the combination of these activities, from the two different prompts, would create a very thoughtful and engaging lesson that provides enough support as well as a challenge for all students as needed."

In the second case, they chose to use the AI-generated lesson plan with changes in the design of the lesson plan, from reorganizing the lesson to adding instructional materials that they developed themselves. One PST comment explains this method: "The AI plan provided a good base to go off of, but it is very vague, so I would change it by adding more details so that it is a more thought through lesson plan." Both approaches required work on the part of the PSTs to make instructional decisions and edit or create instructional material to improve the lesson plan.

PSTs justified what they found helpful from the AI-generated lessons and why they wanted to keep these components in their lesson. For one PST, it was the exit ticket, "I thought that the exit ticket did a good job of having students show their understanding of function identities, which was the main point of the lesson." Another PST shared.

"One activity I used from the AI plan was the activity that had students split into either function representatives or identity explorers. I thought this was a really cool way for students to get to explore functions while still requiring them to use their thinking skills since they need to be able to understand different equations and the components of the function they were given. I changed this activity a little bit to have it focus more on the functions identities and checking their work rather than having them relate the functions identities to individuals' group affiliations and identities."

These comments point towards the benefits of PSTs using AI chatbots as a resource if used with caution and knowledge to make changes to improve AI-generated content.

5.6. PSTs Changed AI-Generated Content to Make it Appropriate for their Use

This assignment was the first time all six PSTs used an AI chatbot to develop mathematics lesson plans. Engaging in the activity allowed them to experience using AI with caution and to position themselves as experts to improve the lesson plans generated by the AI chatbot. As described here, PSTs' adaptations fell into a few categories: scaffolding, engagement, and differentiation.

5.6.1. Scaffolding

All the PSTs wanted their lesson plans to align with their teaching style. If they used the AI-generated lesson plans, they reorganized them and added components they thought would be needed to implement the lesson plan in their own teaching style. When using educational materials such as worksheets or discussion prompts, they made instructional decisions about when to use them in the lesson and changed them as they saw fit. PSTs preferred more scaffolded lessons that allowed students time to engage in an activity to foster learning. One PST shared.

"The AI plan expected students to trace circles and then simply look at the numbers, create ratios, observe the ratios, and then come to the realization that all circles are similar. I thought that this was a big, unrealistic jump that students were expected to just uncover. I, instead, created a guide that students would work through as they were completing the hands-on activity; I thought that it provided scaffolding to the activity so that students did not feel as lost."

This PST created guidelines for students to feel engaged in the activity. Another PST used an *I-do, We-do, You-do* approach to envision a smooth implementation of the lesson and shared, "I would provide examples where I model it and then I would also do examples where we do it together." The same PST said they would "do more math-related and *real-life examples* … that way, students can see that we use these concepts outside of math class." This PST wanted to provide examples and direct instruction to the students so they could understand the concepts. All the PSTs generally leaned towards including greater instructional time in the lesson plans.

5.6.2. Engagement

PSTs also wanted to ensure the students would be engaged in the lesson and not feel lost. One PST described this concern well.

"Another thing that I changed from the AI lesson plan was creating an activity as opposed to simply giving a worksheet or an assessment after the notes segment. I did this because in high school classrooms, engagement and motivation are often lower, so creating a more interactive activity for them to practice the new skills is more aligned to my teaching style."

For this PST, their perception of a high school classroom influenced their decision to make pedagogical changes in the lesson to make it more engaging for their students. Another PST changed the AI lesson plan to keep their students engaged; the PST explained.

"The discussion on the relation to the social justice issue in the AI plan is just talking between the teacher and the students. While this is acceptable, I feel that students will become disengaged quickly, and I would not want sensitive activities to be something that students check out for. Thus, I created the PowerPoint so that both the teacher and the students had a physical resource to follow along with and write in. Students could view this document on their own Chromebooks. I could also include Padlets in the slides so that students have a way to anonymously answer questions."

Here, the PST was mindful of providing several ways for students to participate in a discussion instead of just a conversation between teacher and students, which may or may not be effective. This PST also allowed students to share anonymous responses if they felt uncomfortable participating in a large group discussion. Such thoughtful ideas allowed the PSTs to add details to the lesson plans that would enable more of their students to participate in the discussion. PSTs wanted their students to have a successful learning experience; their comments show a caring attitude toward their student's learning. They used AI-generated lesson plans cautiously while being mindful of how their students would react when implemented in a real classroom.

5.6.3. Differentiation

PSTs wanted their lesson plans to be inclusive and cater to the needs of all their students. They included in their lesson plans support for English Language Learners (ELL), as one PST shared.

"Another thing I would change about the AI-generated lesson plan is to add more support for ELL students and more differentiation based on student need. The AI lesson plan did not have much of this, however this is very important to have in a lesson plan and to think about in order to support your students appropriately."

This PST added the following supports in their final lesson plan.

"Color code the different identities/pieces of the function. For example, domain could be written in red and the range in blue; Definition sheet - provide a definition sheet in both English and their home language; Include pictures like graphs or tables for students to use to determine the identities; Provide example work for the identity maps so students know what their product will look generally like"

Another PST shared a similar thought, "My differentiation also acknowledged different types of learners (auditory vs visual, physical vs online, etc.). It also included accommodations for ELL learners." In addition to differentiating their instruction, some PSTs added various ways their students could check their work and take charge of their learning. For example, one PST shared, "I also added that students should use Desmos to check how well they were able to understand the different pieces of the function because I thought this was a good way for students to self assess and correct any errors they may have had." This activity would allow students to learn at their own pace. PSTs' knowledge of differentiating instruction allowed them to develop lesson plans that had the potential to reach all their students.

6. DISCUSSION

Our findings align with existing research in that teachers need to use caution when using resources (Dick, Sawyer, Shapiro, & Wismer, 2021; Sawyer, 2024). Teachers' expertise regarding content and pedagogy guides them in making instructional decisions and selecting resources to aid their students' learning (Ball, Lubienski, & Mewborn, 2001). There is some literature to support the development of PSTs' CK and PCK to help them become effective

teachers (Kunter et al., 2013; Park & Oliver, 2008). However, there is a need to support PSTs in perceiving AI chatbots as tools that need to be critically used by teachers when developing instruction, especially when it comes to pedagogical ideas that may be new to them. This requires the development of their CK and PCK.

6.1. More Confidence in CK and PCK Means More Critical

The data suggests that the secondary PSTs had confidence in their Mathematical and Pedagogical Content Knowledge, making them more critical of the AI-generated lesson plans. In the past investigation, the majority of the elementary PSTs copied the materials verbatim from the AI chatbot without any criticality despite having been previously taught Critical Curation (Sawyer, 2024). However, all secondary PSTs constructed some form of adaptation or change of their AI-generated lesson plan, making the AI chatbot more of a resource than a full curriculum developer.

Sawyer (2024) found that only 13.6% of the resources created by the elementary PSTs were edited regarding mathematical content. This investigation demonstrated that all secondary PSTs critiqued the mathematics content to support their students' needs.

Both the elementary and secondary PSTs recognized the vague nature of the AI-created resources. The secondary teachers did something about the vague responses by making their own instructional material. They were confident in their knowledge and abilities to the extent that they saw themselves as experts over the AI tool. This finding suggests that with more mathematical content knowledge and pedagogical knowledge, a PST might be more critical of AI-generated lesson plans.

6.2. CK, PCK, and TK Influence AI Use for Educational Purposes

While findings did not show a reliance on TK to assess AI-generated lesson plans, the experience of generating AI lesson plans that align with their teaching standards provided an opportunity for the PSTs to learn about the limitations of AI as well as how to input specific prompts to get a reasonable response from AI. This study highlights that improving PSTs' TK may not be sufficient for the meaningful use of AI tools. PSTs with better command of their CK and PCK could identify the deficits in the AI-generated lesson plans. The experience of using AI tools to develop lesson plans may allow PSTs to develop their TPK. Students who were more critical of the AI generated work took more caution about the prompts they used in developing the lesson plans. PSTs critiqued the lesson plan and the sequencing of activities in the generated lesson plan. Lesson planning and sequencing, as they connect to technology, are key facets of TPK development (Figg & Jaipal, 2009). PSTs who critiqued the chatbot-generated work seem to have curated the use of technology guided by their CK and PCK. PSTs' use of a critical lens when using technology could also be based on their own biases.

One PST was especially influenced by their biases regarding the importance of mathematical CK versus PK. This particular PST was cautious about the mathematical content or activities generated by the AI but seemed to give more agency to the AI chatbot regarding pedagogical aspects of the lesson plan, such as how the lesson was organized time allocated for different activities, and assessments generated by the AI tools. More research is needed to learn about PSTs' biases regarding the importance of pedagogical content knowledge and the influence this bias might have on their AI use. For example, if a PST perceived mathematical CK to be of greater importance than PCK, would they be less critical of pedagogical aspects of AI-generated instructional materials? Findings from such research could guide mathematics teacher preparation, especially regarding the use of AI tools.

7. LIMITATIONS

This investigation looked into a single class using a single AI chatbot—Bard, which has been renamed Gemini. The AI literature explained that different AI chatbots could produce different results based on the data they were trained on; thus, they could create various lesson plans that might be more mathematically sound (Barilla, 2024). Also, this study was conducted in Fall 2023, and since these tools are ever-changing based on updates, one must consider that the current responses would be different than those created at that time.

8. IMPLICATIONS

The study has specific implications for the mathematics education field. First, it helps support MTEs by providing them with possible ways to help PSTs overcome their overconfidence in AI chatbots. Second, the data from this investigation supports the idea that professional development is needed to support teachers' use of AI tools as educational resources. Finally, the data indicate that using AI chatbots as an educational tool can support teachers' development of TPK.

8.1. Developing PSTs' Confidence to Help Them Be Critical

An essential role of MTEs is to guide the development of criticality in PSTs. Sawyer (2024) investigation indicated that classroom discussions on the critical use of AI chatbots were not enough to support PSTs from being overconfident in the abilities of the AI chatbot. PSTs needed further support to become critical users of AI chatbots. The current investigation provides a new avenue for MTEs to develop PSTs' criticality required to support all students' learning in the mathematics classroom. If the PSTs need to be more critical, the MTE must first build the PSTs' confidence in their PCK and CK. Suppose a PST chooses to use AI chatbots to develop their lesson plans without any concerns about the quality of the outputs regarding pedagogy or mathematical content. In that case, the MTE needs to develop the PST's skill set in those areas that might lead the PST to become more critical of AI-generated instructional materials.

8.2. More PD is Needed for AI

This investigation also implies that more professional development tools and programs must be constructed to help inservice teachers use AI tools. Secondary education students, like elementary education students, believed that the AI chatbot could help support the creation of resources for their mathematics classroom. However, more research is needed to learn ways to support inservice and preservice teachers in becoming critical curriculum developers.

8.3. AI Chatbot Use for Instructional Purposes Supports the Development of TPK

AI chatbots are one of the newest tools available to support teachers. Our findings indicate that AI tools can help teachers learn about TPK. Developing experiences for inservice and preservice teachers to engage with AI tools can help them build a new understanding of technology in the classroom. Professional development opportunities and in-class activities could be constructed to support teachers' knowledge of TPK through engagement with AI chatbots. Since teachers can use these tools, MTEs are responsible for providing the necessary skills to help build their TPK and support all future learners in their classrooms.

9. CONCLUSION

The findings from this investigation stress the need to support PSTs in using AI chatbots critically. This means positioning PSTs as experts who perceive AI chatbots as a mere tool. PSTs must understand that while using this

tool, the onus of critiquing AI-generated responses falls on the user. Our findings demonstrate the need for teacher education programs to provide experiences for PSTs to build their CK and PCK and use this knowledge to critique new technology they can use as teachers. Engaging PSTs in the guided use of AI chatbots for curriculum development can help them develop their TPK. Hence, the benefits of such activities can be twofold.

Based on our findings, we recommend designing and providing professional development activities for inservice teachers to familiarize themselves with AI chatbots as curriculum development tools. Inservice teachers bring a wealth of knowledge and experience to professional development programs. Their engagement with AI chatbots can provide insights into the pitfalls of using AI chatbots and guidelines about better use of these tools. Supporting inservice and preservice teachers can help guide them in using AI tools to create curriculum materials for their mathematics classrooms. Developing their confidence might help them develop the criticality needed to support effective learning for all students.

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