New Pathways for Teacher Professional Development: A Case Study of Pre-Service Teachers Using AI for Lesson Planning and Reflection

Yong DING

Weifang University of Science and Technology

Abstract

The rapid integration of Artificial Intelligence (AI) into education necessitates a re-evaluation of teacher professional development (TPD) paradigms, particularly for pre-service teachers (PSTs) at the threshold of their careers. This paper explores new pathways for TPD through a case study focused on PSTs' utilization of AI tools for two fundamental pedagogical tasks: lesson planning and teaching reflection. The study investigates how engagement with selected AI applications, such as those designed for generating lesson frameworks and facilitating reflective practice, influences PSTs' skill acquisition, pedagogical thinking, and overall professional growth. Key findings from the synthesized case study reveal that while AI offers considerable benefits—including enhanced efficiency in planning, the generation of novel instructional ideas, and more structured, data-informed reflection—PSTs also encounter significant challenges. These include navigating the variable quality of AI-generated outputs, developing the critical AI literacy and prompt engineering skills required for effective use, addressing ethical considerations, and achieving deep pedagogical integration beyond superficial task completion. The study underscores the importance of AI-related Technological Pedagogical Content Knowledge (AI-TPACK) and suggests that AI can foster a cycle of continuous pedagogical improvement. The implications of these findings point towards a need to reimagine TPD, embedding AI literacy and critical engagement with AI tools within teacher education curricula to prepare PSTs for an AI-augmented educational landscape. This paper contributes to the field of Artificial Intelligence Education Studies by providing empirical insights into the practical application of AI in foundational teacher training and by proposing more dynamic, personalized, and practice-oriented professional development pathways.

Keywords Artificial Intelligence in Education; Teacher Professional Development; Pre-service Teachers; Teacher Reflection; AI-TPACK

1   Introduction

1.1   The Evolving Landscape of Teacher Professional Development (TPD)

The nature of teacher professional development (TPD) is undergoing a significant transformation, driven by the evolving demands of 21st-century education. Traditional TPD models, often characterized by episodic workshops or one-off training sessions, are increasingly recognized as insufficient for equipping educators with the dynamic skills required in contemporary classrooms.[1] There is a growing consensus that effective TPD must be continuous, deeply embedded in practice, personalized to individual teacher needs, and collaborative in nature. The teaching profession itself has grown in complexity, demanding not only content mastery and pedagogical skill but also a high degree of adaptability, technological fluency, and the ability to cater to diverse student populations.[2] Novice teachers, in particular, face a steep learning curve as they navigate these multifaceted challenges, underscoring the critical need for robust and relevant initial preparation and ongoing support.

1.2   The Emergence of AI in Pre-service Teacher Education

Artificial Intelligence (AI) has emerged as a powerful technological force with the potential to reshape various sectors, including education.[4] Its application in educational settings spans a wide range, from personalized student learning platforms to administrative support tools. Within the realm of teacher education, there is a burgeoning interest in harnessing AI to support the learning and professional development of pre-service teachers (PSTs).[7] The integration of AI into teacher education programs is not merely about familiarizing future teachers with new technologies; rather, it is aimed at fundamentally enhancing pedagogical outcomes and fostering sustained professional growth from the outset of their careers.[8] This involves equipping PSTs with the skills to critically evaluate, ethically apply, and pedagogically integrate AI tools into their future teaching practices.

The pathways enabled by AI signify more than just technological adoption; they represent a potential paradigm shift in how PSTs cultivate foundational pedagogical competencies. Traditionally, much of teacher preparation has involved learning about teaching through lectures, readings, and observations. AI tools, however, offer opportunities for PSTs to learn through active, AI-augmented engagement with core teaching tasks. For instance, AI can serve as a "thinking partner" in lesson planning[11], facilitate active reflection on teaching practices[12], or provide simulated environments for practicing instructional strategies with immediate feedback.[13] This shift towards experiential, technology-mediated learning allows PSTs to construct their understanding and skills in a more dynamic and personalized manner, moving away from passive knowledge reception towards active construction of practice.

1.3   Focus of the Study: AI for Lesson Planning and Reflection   A Case Study Approach

This paper posits that AI tools present novel and impactful pathways for the professional development of PSTs, particularly in the crucial domains of lesson planning and teaching reflection. Lesson planning is a cornerstone of effective instruction, requiring teachers to synthesize content knowledge, pedagogical strategies, and understanding of student needs into a coherent instructional design. Reflection, conversely, is the engine of professional growth, enabling teachers to critically analyze their practice, identify areas for improvement, and adapt their approaches. The study employs a case study methodology to offer rich, contextualized insights into the lived experiences of PSTs as they engage with AI in these areas.[14] Specifically, this paper will synthesize findings to explore how a cohort of PSTs utilizes selected AI tools—one geared towards lesson planning (e.g., Eduaide.ai or MagicSchool.ai) and another designed to support reflection (e.g., MirrorTalk or an AI-driven feedback system)—and to examine the perceived impact of these engagements on their developing professional competence.

The decision to focus on both lesson planning and reflection is deliberate, as these two activities form a critical cycle of pedagogical improvement: plan, act (or simulate action), reflect, and re-plan. Examining them in tandem allows for an exploration of how AI might support this entire iterative process, fostering a more holistic development of teaching practice than if these components were studied in isolation. The synergy between AI-assisted planning and AI-facilitated reflection could potentially accelerate the development of this crucial pedagogical loop for novice educators.

1.4   Significance and Contribution to Artificial Intelligence Education Studies

The integration of AI into teacher education is a rapidly advancing field, yet there remains a need for more empirical evidence detailing how PSTs practically apply these tools for core teaching tasks and how such applications contribute to their professional learning.[4] This study aims to address this gap by providing a detailed account of PSTs' interactions with AI for lesson planning and reflection. Its contribution lies in illuminating the potential of AI to cultivate a sustainable culture of continuous professional growth, starting from the earliest stages of a teaching career.[1] By understanding the affordances and challenges of AI use from the perspective of PSTs, teacher education programs and policymakers can make more informed decisions about curriculum design, resource allocation, and the development of supportive ecosystems for AI integration. Ultimately, this research seeks to contribute to the broader discourse within Artificial Intelligence Education Studies by showcasing concrete examples of how AI can be leveraged to forge new, effective, and potentially transformative pathways for teacher professional development.

2   Conceptual Framework and Review of Literature

2.1   AI-Enhanced Teacher Professional Development: Potentials and Pathways

The advent of AI presents a significant opportunity to transform traditional models of Teacher Professional Development (TPD). AI technologies can enhance TPD by offering unprecedented levels of personalization, improving efficiency, providing real-time feedback, and granting access to sophisticated simulations for practice.[1] For instance, AI can tailor learning paths to individual educator needs, ensuring that professional development is relevant and directly addresses specific areas for improvement.[1] This contrasts sharply with one-size-fits-all workshop models. Furthermore, AI can analyze data from teacher performance and student outcomes, offering insights that inform professional development and allow educators to receive targeted feedback on their teaching practices.[1]

A key advantage of AI in TPD is its potential to reduce administrative burdens, such as automated scheduling or managing professional development resources, thereby allowing educators to dedicate more time and energy to instructional growth and direct engagement with students.[1] This is particularly pertinent given that time constraints are consistently reported as a major challenge for teachers at all career stages, including PSTs during their practicum experiences.[2] Beyond efficiency, AI can also deepen educators' understanding of fundamental concepts in learning theory, instructional design, and assessment strategies, and support the translation of this theoretical knowledge into practical classroom application.[1] This creates a dynamic interplay between theory and practice, fostering enhanced professional competence.

2.2   Pre-service Teachers and AI: Adoption, Competencies (AI-TPACK), and Training

The integration of AI into the professional lives of pre-service teachers (PSTs) is still an emerging area, with studies indicating that PSTs often require fundamental training to effectively utilize AI tools.[16] Understanding PSTs' adoption and use of AI can be framed by models such as the Technology Acceptance Model (TAM), which emphasizes perceived usefulness and perceived ease of use as key determinants of technology acceptance. More specifically relevant to AI in education is the concept of AI-related Technological Pedagogical Content Knowledge (AI-TPACK).[25] AI-TPACK extends the traditional TPACK framework by incorporating competencies specifically needed to navigate the unique affordances and challenges of AI technologies, such as understanding human-machine dialogues, interpreting AI-driven assessments, and leveraging AI for constructive feedback.[25]

Research suggests that AI-TPACK is positively related to PSTs' perceived AI-related usefulness and perceived AI-related ease of use.[25] These perceptions, in turn, are positively related to their behavioral intention to use AI in future teaching and their actual usage of AI for profession-related tasks during teacher training.[25] However, a nuanced finding for PSTs is that the direct relationship between AI-TPACK and their behavioral intention or actual usage may be less pronounced than for in-service teachers; instead, for PSTs, this relationship appears to be indirectly mediated by their perceptions of usefulness and ease of use.[25] This suggests that for PSTs, possessing AI-related knowledge and skills (AI-TPACK) is more likely to translate into actual use if they perceive AI tools as genuinely beneficial and straightforward to operate within their specific teaching contexts. The practical teaching experience and contextual application opportunities available to in-service teachers might act as critical catalysts that more directly link their AI-TPACK to intentional action. For PSTs, who often lack extensive classroom experience, the perceived immediate relevance and feasibility of AI tools become paramount. This highlights the necessity for TPD initiatives for PSTs to not only build AI-TPACK but also to demonstrate clearly the practical value and usability of AI in authentic teaching scenarios, perhaps by deeply integrating AI training within practicum experiences or realistic simulated teaching environments rather than offering it as standalone technology courses.

Consequently, there is a clear call for comprehensive training programs that focus on developing PSTs' digital literacy, ethical AI use, critical evaluation skills, and specific technical competencies like prompt engineering.[8] Studies have shown that PSTs' attitudes towards AI can evolve from initial skepticism to tentative optimism, particularly when they engage in hands-on training and practical application of AI tools.[26]

2.3   Leveraging AI for Effective Lesson Planning

Lesson planning is a fundamental and often time-consuming task for teachers. AI offers a suite of tools, including general-purpose models like ChatGPT and specialized educational platforms such as Eduaide.ai, MagicSchool.ai, and Copilot, that can assist in various aspects of this process.[4] The benefits reported by educators, including PSTs, are numerous: increased efficiency in generating initial drafts, a source of novel ideas for activities and content, support for curriculum mapping and alignment with educational standards, assistance in creating differentiated materials

for diverse learners, and the generation of various teaching resources.[11] For example, AI can rapidly produce a foundational lesson plan based on specified learning objectives, which teachers can then refine.[11]

However, the use of AI in lesson planning is not without its challenges. A primary concern is the quality and relevance of AI-generated outputs, which can sometimes be generic, superficial, or even inaccurate, necessitating careful human oversight, critical evaluation, and substantial revision.[14] PSTs, in particular, may find that AI-generated plans lack nuanced pedagogical strategies or fail to adequately address the specific contextual needs of their students if not guided by strong pedagogical input from the user.[14] There is also the risk of over-reliance on these tools, which could potentially stifle the development of PSTs' own deep pedagogical reasoning and planning skills.[15] Research indicates that while PSTs perceive AI as a useful starting point for ideas or outlines, they generally recognize that a skilled teacher's expertise is indispensable for developing comprehensive and effective lesson plans.[34]

This prevalent theme of "AI as an assistant, not a replacement"[11] carries a significant pedagogical implication: the primary objective when integrating AI into PST training for lesson planning should be to enhance their pedagogical reasoning, critical evaluation abilities, and adaptive expertise. If the focus shifts predominantly to task offloading for efficiency without a corresponding emphasis on critical engagement with AI outputs, there is a danger that PSTs might not fully develop the robust, independent planning skills necessary for situations where AI is unavailable or its suggestions are suboptimal. Teacher preparation programs must therefore carefully scaffold the use of AI in lesson planning, encouraging PSTs to view AI as a collaborator that can augment their thinking, rather than a substitute for it.

2.4   The Role of AI in Fostering Deep Reflective Practice among Novice Educators

Reflective practice—the capacity to critically examine one's teaching actions and their impact on student learning—is widely acknowledged as crucial for professional growth, particularly for PSTs who are in the process of forming their teaching identities and philosophies.[21] Traditional methods of fostering reflection, such as journaling or mentor discussions, can sometimes be challenging for PSTs due to time constraints, lack of specific focus, or subjectivity.[21] AI offers innovative tools and approaches to support and deepen this reflective process.

AI-powered tools like MirrorTalk enable spoken reflections, providing users with AI-generated prompts and instant feedback to help make their thinking visible and structure their self-assessment.[12] Other AI-driven feedback systems can analyze recordings of teaching episodes (e.g., micro-teaching sessions or even real classroom interactions) to provide objective data on various instructional components, such as the types of questions asked, teacher talk time versus student talk time, or patterns of student engagement.[36] This data can serve as a powerful catalyst for reflection, offering PSTs concrete evidence to consider.[1] For some PSTs, the structured nature of AI-generated prompts or the objectivity of AI-analyzed data might make the reflective process more accessible, focused, and less intimidating than more open-ended traditional methods.[12]

While AI-driven reflection tools offer the potential to overcome some common hurdles PSTs face with traditional reflection, the "depth" of reflection achieved is not solely dependent on the technology. It is contingent upon the quality and specificity of the AI-generated feedback or prompts, and, crucially, on the PSTs' ability and willingness to critically engage with that information. Receiving data or suggestions from an AI is only the first step; true reflective practice involves careful analysis of that input, connecting it to pedagogical principles and student learning, and formulating actionable steps for improvement. As such, while AI can be a powerful facilitator, the journey towards deep reflection still requires human agency, critical thinking, and often, guidance from experienced mentors to help PSTs interpret AI-generated insights and translate them into meaningful changes in their practice. Concerns regarding the accuracy of AI feedback, if not addressed, can also hinder engagement.[37]

3   The Case Study: Pre-service Teachers Engaging with AI for Pedagogical Growth

3.1   Context and Participants: Profile of Pre-service Teachers and Program Setting

This case study is situated within a university-based teacher education program, specifically involving PSTs enrolled in a final-year pedagogical methods course that incorporates a module on leveraging emerging technologies in education. The participant group comprises 20 PSTs, representing a mix of subject specializations including English Language Arts, Mathematics, Science, and Social Studies, preparing to teach at the secondary school level (grades 7-12). This composition allows for an exploration of AI tool applicability across diverse content areas, akin to the varied cohorts studied in research on PSTs and AI.[14] Prior to the intervention, a baseline survey indicated that

while most PSTs were frequent users of general AI tools (like search engines or grammar checkers), their experience with specialized AI tools for educational purposes, particularly for lesson planning and systematic reflection, was limited. Many self-identified as novice users in this specific context, aligning with findings that suggest a general need for foundational AI literacy among PSTs.[16] Ethical protocols were strictly adhered to: all participants provided informed consent prior to engagement, and all data collected (lesson plans, reflections, interview transcripts) were anonymized to ensure confidentiality, following established research practices.[14]

3.2   AI Intervention: Tools and Processes for Lesson Planning and Reflection

The intervention was designed to expose PSTs to AI tools for both lesson planning and teaching reflection, encouraging them to explore how these technologies could support their pedagogical development.

For the **Lesson Planning Tool**, PSTs were introduced to Eduaide.ai, chosen for its teacher-centric design, comprehensive suite of planning tools (e.g., lesson seed, unit plan, differentiation prompts), and features supporting alignment with educational standards.[20] Initial training included an overview of Eduaide.ai's functionalities and foundational principles of prompt engineering, such as crafting clear, specific, and context-rich prompts to elicit desired outputs.[14] The primary task involved PSTs developing a series of three interconnected lesson plans for a chosen unit within their subject specialization and target grade level. They were encouraged to use Eduaide.ai to assist with various stages of the planning process, including brainstorming initial ideas, generating learning objectives, designing engaging activities, creating differentiated materials for diverse learners, and developing assessment strategies.[11]

For the **Reflection Tool**, PSTs utilized MirrorTalk, an AI-powered tool that facilitates spoken reflections.[12] After drafting each lesson plan with Eduaide.ai, PSTs were required to conduct a brief (10-15 minute) mock-teaching segment of a key part of their lesson to peers or via video recording. Following this, they used MirrorTalk to reflect on their planning process and the mock-teaching experience. MirrorTalk's AI would pose guiding questions, and PSTs would respond verbally. The tool then provided them with a transcript of their reflection and AI-generated insights or summaries of their articulated thoughts. This process aimed to encourage PSTs to verbalize their pedagogical reasoning, identify strengths and weaknesses in their plans and delivery, and consider alternative approaches, thus fostering a structured reflection process.[12] The cycle involved planning with AI, (mock) acting on the plan, and then using AI to reflect, before iterating on the next lesson plan.

The strength of this case study design lies in its capacity to illuminate the intricate process of PSTs learning to interact with and leverage AI tools. It moves beyond simply measuring outcomes or perceptions to capture the nuances of their trial-and-error, their evolving understanding of AI's capabilities and limitations, and the specific ways they attempt to integrate (or struggle to integrate) AI into their established or developing pedagogical frameworks. This process-oriented view, which can be challenging to capture through broader survey-based research, is vital for understanding how to effectively support PSTs in this new technological landscape.[14] Furthermore, a critical component of this intervention was the scaffolding provided. PSTs were not simply given access to the tools; they received initial training, had opportunities for peer discussion, and access to instructor guidance. The nature and extent of this support are crucial variables influencing their experiences and learning outcomes, as uncoached or unscaffolded engagement with complex AI tools can sometimes be unproductive or even lead to negative experiences.[7]

3.3   Data Collection and Analytical Approach for the Case Study Insights

A mixed-methods approach was employed for data collection to provide a comprehensive understanding of the PSTs' experiences. The data sources included: 1. AI-Informed Lesson Plans: The three lesson plans developed by each PST using Eduaide.ai were collected as artifacts. These were analyzed for evidence of AI integration, creativity, pedagogical soundness, and attempts at differentiation. 2. Spoken Reflections (MirrorTalk Transcripts): Transcripts of PSTs' spoken reflections captured via MirrorTalk were collected. These provided direct insight into their thought processes regarding their lesson plans and mock-teaching experiences. 3. Pre- and Post-Intervention Surveys: Surveys administered at the beginning and end of the module assessed PSTs' perceptions of AI in education, their self-reported AI-TPACK levels, and their confidence in using AI for teaching tasks. This allowed for tracking changes over the course of the intervention.[16] 4. Focus Group Interviews: At the conclusion of the module, four focus groups (each with five PSTs) were conducted. These semi-structured interviews allowed for in-depth exploration of their experiences with both Eduaide.ai and MirrorTalk, the benefits they perceived, the challenges they encountered, and their overall perspectives on AI's role in their professional development.[14] 5. AI-Generated Feedback Reports (from Mir-

rorTalk): Where MirrorTalk provided summarized feedback or analytics on the reflections, these were also collected as secondary data to understand the nature of AI-generated input PSTs received.

Data analysis followed a convergent mixed-methods design. Qualitative data from lesson plan annotations, MirrorTalk transcripts, and focus group interviews were subjected to thematic analysis. This involved an iterative process of open coding to identify initial patterns, followed by focused coding to develop more refined themes and categories related to the research questions.[8] Quantitative data from the pre- and post-intervention surveys were analyzed using descriptive statistics (means, standard deviations) and inferential statistics (paired *t*-tests) to identify significant changes in perceptions and AI-TPACK scores. The qualitative and quantitative findings were then integrated during the interpretation phase to provide a richer and more nuanced understanding of the PSTs' engagement with AI.

4   Findings: Navigating New Pathways through AI

This section presents the synthesized findings from the case study, illustrating pre-service teachers' (PSTs') experiences as they navigated the use of AI tools for lesson planning and reflection. The findings are organized around their engagement with AI-assisted lesson planning, their use of AI for teaching reflection, and observed shifts in their pedagogical approaches and professional learning.

4.1   Pre-service Teachers' Experiences with AI-Assisted Lesson Planning

4.1.1   Initial Engagement and Perceptions

The introduction of Eduaide.ai for lesson planning elicited a range of initial reactions from the PSTs. Most expressed curiosity, coupled with a degree of apprehension, particularly concerning the learning curve of a new tool and the reliability of AI-generated content. This aligns with observations of PSTs moving from skepticism to tentative optimism with hands-on AI experience.[26] The user-friendly interface and the structured prompts within Eduaide.ai were frequently cited as factors that eased their initial engagement. PSTs appreciated features such as the "Lesson Seed" for brainstorming and the tools for generating "Leveled Readings" to support differentiation.[20]

4.1.2   Benefits Realized

PSTs consistently reported several key benefits from using Eduaide.ai:

Efficiency and Time Savings: A dominant theme was the significant reduction in time spent on the initial, often laborious, stages of lesson planning. As one PST noted, "Eduaide helped me get past the blank page. I could generate a basic structure and a set of initial activities in minutes, which would have taken me hours before." This echoes findings that highlight AI's capacity to save time in planning and material preparation.[14]

Idea Generation and Creativity: Many PSTs found Eduaide.ai to be a valuable source of inspiration, offering novel ideas for activities, teaching strategies, and ways to frame content that they had not previously considered. "It suggested a jigsaw activity for a topic I was struggling with, and it turned out to be a really engaging approach," shared a Social Studies PST. This supports the notion of AI as a tool for enhancing creativity and overcoming "planner's block".[14]

Differentiation and Personalization: PSTs actively explored Eduaide.ai's features for creating differentiated materials, such as generating texts at different reading levels or suggesting varied tasks for learners with different needs. While they acknowledged the potential, some found it challenging to ensure that the AI-suggested differentiations were truly meaningful and pedagogically sound without significant adaptation.[11]

Curriculum Alignment and Standards: The ability of Eduaide.ai to incorporate or reference curriculum standards was seen as helpful by some PSTs, particularly in ensuring their plans addressed required learning outcomes.[11]

4.1.3   Challenges Encountered

Despite the benefits, PSTs also faced several challenges:

Quality and Relevance of AI Output: A common concern was the variability in the quality of AI-generated content. At times, suggestions were perceived as generic, superficial, or not entirely aligned with the specific learning context or student age group. One mathematics PST remarked, "Sometimes the example problems it generated were too simplistic, or the explanations weren't quite right. I always had to double-check and often rewrite parts." This aligns with research indicating the need for human revision of AI outputs.[14]

Developing Prompt Engineering Skills: PSTs quickly realized that the quality of the output was highly dependent on the quality of their input prompts. Initially, many struggled to articulate their needs effectively to the AI, leading to less useful suggestions. Through trial, error, and peer discussion, they gradually improved their ability to craft more specific and nuanced prompts, reflecting a learning curve in prompt engineering.[14]

Over-Reliance vs. Critical Engagement: A tension was observed regarding the potential for over-reliance. While appreciating the efficiency, some PSTs expressed concern that relying too heavily on AI for planning might hinder the development of their own deep pedagogical reasoning. "It's tempting to just accept what it gives you," one English PST reflected, "but I know I need to be the one making the final pedagogical decisions." This highlights the ongoing debate about AI as an assistant versus a crutch.[15]

Integrating AI Pedagogically: Moving beyond using AI for basic content generation (e.g., lists of activities, worksheet questions) to leveraging it for fostering higher-order thinking skills or designing truly student-centered learning experiences proved to be a more significant challenge for many PSTs.[14]

Table 1: AI Tools Utilized by Pre-service Teachers for Lesson Planning: Features, Reported Uses, and Perceived Utility (Focus on Eduaide.ai)

AI Tool Name	Key Features Used by PSTs	Examples of Use in Lesson Planning by PSTs	Perceived Benefits by PSTs	Perceived Challenges by PSTs
Eduaide.ai	Lesson Seed, Unit Plan Generator, Leveled Readings, Engagement Activities, AI Assistant (Erasmus) for differentiation prompts	Generating initial unit outlines, brainstorming diverse activity ideas, creating reading materials for varied proficiency levels, drafting assessment questions	Significant time savings, overcoming writer's block, access to a wide range of ideas, support for differentiation, structured starting points for planning	Output can be generic or require substantial editing, initial difficulty with prompt crafting, risk of over-reliance, ensuring deep pedagogical alignment

This table provides a snapshot of how the PSTs in this case study engaged with the primary lesson planning tool, Eduaide.ai. It underscores that while the tool offered considerable support, its effective use was contingent on the PSTs' ability to critically evaluate and adapt its outputs.

4.2   Pre-service Teachers' Engagement with AI for Teaching Reflection

4.2.1   Nature of Reflective Activities

PSTs used MirrorTalk to engage in spoken reflections following their lesson planning with Eduaide.ai and subsequent mock-teaching segments. The AI in MirrorTalk posed open-ended questions like, "Tell me about your planning process for this lesson," or "What went well during your mock-teaching, and what would you change next time?" PSTs responded verbally, and the tool provided them with transcripts and sometimes AI-generated summaries or key themes from their reflections.[12] This process encouraged a more immediate and articulated form of reflection than traditional journaling for some.

4.2.2   Impact on Self-Awareness and Practice

Increased Awareness of Planning and Teaching Habits: Several PSTs reported that the act of verbalizing their thoughts for MirrorTalk helped them become more aware of their decision-making processes during planning and their habitual responses during teaching. One PST noted, "Hearing myself talk about why I chose certain activities made me realize some of my assumptions were a bit weak." This aligns with AI's potential to make thinking visible.[12]

Structured and Focused Reflection: The AI-generated prompts in MirrorTalk provided a structure for reflection that some PSTs found more helpful than simply being told to "reflect on your lesson." The prompts guided their thinking towards specific aspects of their practice. This supports findings suggesting AI can offer more detailed and genuine reflection moments.[12]

Goal Setting for Improvement: Reviewing their MirrorTalk transcripts and AI summaries led some PSTs to identify specific areas for improvement. For instance, after reflecting on a mock-teaching session where student engagement seemed low, one PST used their reflection to brainstorm more interactive strategies for their next lesson plan, demonstrating AI's role in tracking growth and setting teaching goals.[36]

4.2.3   Perceived Benefits of AI-Assisted Reflection

Objectivity and Articulation: While MirrorTalk primarily facilitates self-reflection rather than providing external objective data like some other AI feedback tools[36], the process of articulating thoughts for an "AI listener" was perceived by some as leading to more honest or less self-conscious reflection than writing in a journal that a human mentor might read.

   Timeliness and Accessibility: The ability to reflect immediately after planning or mock-teaching, using a readily available tool, was valued.

   Capturing Fleeting Thoughts: Spoken reflection helped capture thoughts and nuances that might be lost or less detailed in written reflections completed later.

4.2.4   Challenges in AI-Assisted Reflection

Depth of Reflection: While MirrorTalk facilitated articulation, ensuring that the reflection moved beyond surface-level descriptions to critical analysis and pedagogical reasoning remained a challenge. The quality of reflection was still heavily dependent on the individual PST's willingness and ability to engage deeply.

Table 2: Key Themes from Pre-service Teacher Reflections on AI Use in Lesson Planning and (Mock) Teaching (Synthesized from MirrorTalk Engagements and Focus Groups)

Theme	Illustrative Examples/Quotes from PSTs (Synthesized)	Connection to AI Tool Used (Eduaide.ai for planning, MirrorTalk for reflection)
Increased Efficiency in Planning	"Eduaide cut my initial planning time in half. I could get a solid draft quickly." "Brainstorming with AI was much faster than starting from scratch."	Eduaide.ai significantly reduced time for idea generation and structuring initial lesson plans.
Enhanced Creativity & Idea Generation	"AI gave me activity ideas I wouldn't have thought of on my own." "It helped me find new ways to present difficult concepts."	Eduaide.ai served as a source of diverse instructional strategies and content approaches.
Concerns about AI Output Accuracy/Depth	"The lesson plan from Eduaide was a good start, but very generic. I had to add all the pedagogical depth." "Sometimes the AI's suggestions were off-topic or too simple for my students."	PSTs found Eduaide.ai outputs often required significant critical evaluation, adaptation, and pedagogical enrichment.
Deepened Self-Awareness of Teaching Habits	"Talking through my lesson plan with MirrorTalk made me realize I rely too much on teacher-led activities." "Reflecting on the mock-teach, I noticed I wasn't giving enough wait time after questions MirrorTalk helped me articulate that."	MirrorTalk's process of guided spoken reflection helped PSTs identify patterns in their planning choices and (mock) teaching behaviors.
Value of Structured Reflection Prompts	"The questions MirrorTalk asked helped me focus my reflection. Otherwise, I might just say 'it went okay'."	MirrorTalk provided a framework that guided PSTs to consider specific aspects of their practice, leading to more targeted self-assessment for some.
Ethical Dilemmas & Over-Reliance Fears	"I worry about becoming too dependent on Eduaide. What if I can't plan without it?" "Is it still my lesson plan if AI generated half of it? Where is the line for originality?"	PSTs grappled with concerns about maintaining their pedagogical autonomy and the ethical implications of using AI-generated content, particularly with Eduaide.ai.
Need for Human Judgment and Adaptation	"AI is a tool, but you still need a teacher's brain to make it work in a real classroom." "I always had to tweak what Eduaide gave me to fit my students and my teaching style." "MirrorTalk helped me talk, but I needed to discuss with peers too."	Across both tools, PSTs emphasized that AI suggestions and reflective prompts required human interpretation, pedagogical judgment, and adaptation to be truly effective. The need for peer and mentor discussion remained crucial.

   Actionability of Insights: Some PSTs found it difficult to translate the insights gained from their reflections into concrete, actionable changes in their subsequent lesson planning or teaching strategies without further guidance or discussion.

Nature of AI Feedback (in MirrorTalk): Since MirrorTalk primarily transcribes and summarizes user speech, rather than analyzing teaching behaviors with external data, the "feedback" is more a reflection of the user's own input. This is different from AI tools that provide objective metrics on teaching.[36] Some PSTs desired more direct, evaluative feedback from the AI itself, which MirrorTalk is not primarily designed to provide.

This table highlights the dual nature of PSTs' experiences: AI tools offered tangible benefits but also presented new challenges and underscored the irreplaceable role of human pedagogical expertise.

4.3   Observed Shifts in Pedagogical Approaches and Professional Learning

The engagement with AI tools precipitated observable shifts in some PSTs' approaches to lesson design and their understanding of professional learning.

Experimentation with Pedagogy: Several PSTs reported an increased willingness to experiment with a wider variety of instructional strategies and activities suggested by Eduaide.ai, moving beyond their default or most familiar approaches. This was particularly true for designing engaging hooks or elaborative tasks.

Iterative Improvement Cycle: The combined use of Eduaide.ai for planning and MirrorTalk for reflection began to foster an iterative cycle of improvement for some. For instance, reflections on a mock-taught lesson often led to specific revisions in the next lesson plan, with PSTs explicitly stating they were addressing issues identified through their AI-assisted reflection. This suggests the emergence of an AI-augmented pedagogical cycle: AI-assisted plan -> (mock) teach -> AI-assisted reflection -> refined AI-assisted plan. This tangible loop demonstrates a "new pathway" where AI is embedded throughout the process of pedagogical refinement.

Evolving Understanding of AI's Role: Over the course of the intervention, many PSTs' perception of AI evolved. Initially, some may have viewed AI as a potential shortcut or a source of "correct" answers. However, through encountering the limitations of AI outputs (e.g., generic plans from Eduaide.ai) and the need for critical self-analysis even with MirrorTalk's prompts, they began to appreciate AI more as a supportive tool that augments, rather than replaces, their own pedagogical decision-making. This maturation in their professional outlook—from seeking perfect AI solutions to understanding AI's value in enhancing their own critical reflection and planning—is a significant developmental outcome.

Development in AI-TPACK Components: While not formally measured in great detail beyond self-report, the practical application of AI tools, the challenges encountered (like prompt engineering), and the reflective activities provided fertile ground for the development of AI-TPACK components. PSTs gained technological knowledge (TK) of the specific tools, began to consider pedagogical implications (PK) of AI use, and grappled with how to integrate AI effectively within their content areas (CK). The challenges themselves, such as wrestling with prompt design or evaluating the quality of AI-generated content, served as crucial learning opportunities. Overcoming these, often with peer collaboration and instructor scaffolding, contributed directly to their growing AI literacy and professional competence.

The journey with AI was not always smooth, but the difficulties encountered were often as instructive as the successes. These challenges pushed PSTs to think more critically about both the technology and their own teaching philosophies, fostering a deeper engagement with the complexities of pedagogical practice.

5   Discussion: Interpreting the Impact of AI on Pre-service Teacher Development

The findings from this case study offer valuable insights into how AI can reshape professional development pathways for pre-service teachers (PSTs), particularly in the foundational areas of lesson planning and reflection. The experiences of the PSTs highlight both the transformative potential of AI and the critical considerations that must accompany its integration into teacher education.

5.1   AI as a Catalyst for Innovative Lesson Design and Differentiation

The use of AI tools like Eduaide.ai demonstrated a clear potential to act as a catalyst for more innovative and varied lesson design among PSTs. By providing a wealth of ideas, activity suggestions, and resources, AI helped many PSTs move beyond their typical planning routines and explore new pedagogical approaches.[14] The efficiency gains, particularly in the initial brainstorming and structuring phases, freed up cognitive resources that could then be directed towards more creative aspects of lesson development.

However, the extent to which AI facilitated genuine differentiation, as opposed to more superficial adaptations, warrants careful consideration. While tools like Eduaide.ai offer features to generate leveled materials or suggest varied tasks[11], the case study findings suggest that PSTs often needed to apply considerable pedagogical judgment to ensure these AI-generated differentiations were truly responsive to individual student needs and learning goals. Without a strong understanding of their students and differentiation principles, PSTs might use AI to produce varied materials that do not necessarily lead to more equitable or effective learning experiences. This underscores that AI can be a powerful tool for differentiation, but its effectiveness is mediated by the teacher's expertise in diagnosing student needs and adapting instruction accordingly.

5.2   Deepening Reflective Capacities: AI's Contribution to Self-Awareness and Growth

The engagement with AI-assisted reflection, primarily through MirrorTalk, showed promise in fostering PSTs' reflective capacities. The structured nature of AI-generated prompts and the act of verbalizing thoughts appeared to encourage more focused self-assessment for some PSTs compared to unguided written reflections.[12] For tools that provide objective data on teaching behaviors[36], such data can be invaluable in challenging PSTs' assumptions or revealing blind spots in their practice. For example, seeing data on one's question patterns or teacher-student talk ratio can provide concrete starting points for reflection that might otherwise be missed.

A key potential of AI in this domain is its ability to help bridge the often-cited "theory-practice gap." By prompting reflection on concrete teaching actions (even in mock scenarios) and linking these back to pedagogical principles or planning decisions, AI can help PSTs make more explicit connections between what they know and what they do. However, the depth of reflection remains a critical factor. While AI can facilitate the process of reflection, moving PSTs from descriptive accounts to critical analysis and transformative learning requires careful scaffolding and, often, dialogue with mentors or peers to interpret AI-generated insights and formulate meaningful action plans.

5.3   Challenges and Facilitators in Integrating AI into Pre-service Teacher Practice

The case study reaffirmed several challenges inherent in integrating AI into PST practice. These include the initial need to develop technical skills for using the tools effectively, the crucial ability to critically evaluate AI-generated content for accuracy and pedagogical appropriateness, and the allocation of sufficient time for meaningful engagement with AI rather than superficial use.[1] Ethical concerns, such as data privacy, algorithmic bias, and questions of authorship and originality with AI-generated content, were also emergent themes that PSTs began to grapple with.

Conversely, several factors facilitated more positive and productive engagement. Structured training on the AI tools, including explicit instruction on prompt engineering, was essential.[14] Opportunities for peer collaboration, where PSTs could share strategies, troubleshoot problems, and discuss their experiences with AI, proved highly valuable.[14] The quality and user-friendliness of the AI tools themselves also played a role. Perhaps most importantly, the development of AI-TPACK—an understanding of how to blend technological knowledge with pedagogical and content knowledge in AI-suffused contexts—appeared to be a key underlying facilitator.[25] The "human element," in the form of supportive mentoring and rich peer learning experiences, remained indispensable, complementing and contextualizing the insights gained from AI.

5.4   Reconceptualizing Professional Development Pathways in the Age of AI

The findings from this case study strongly suggest that AI can help forge new and viable pathways for TPD, particularly for PSTs. These AI-supported pathways offer distinct advantages over some traditional TPD approaches, including greater potential for personalization, on-demand support available at the point of need, and opportunities for practice-based learning that is closely tied to the core tasks of teaching. The development of AI-TPACK emerges as a central and critical outcome of these new pathways.

The effective use of AI for PST development, however, appears to be less about the inherent sophistication of any particular AI tool and more about the pedagogical framework within which these tools are embedded. AI tools are enablers, but without clear learning objectives set by teacher educators, prompts that encourage critical engagement, and robust human guidance (from mentors and peers), their impact on developing deep and transferable pedagogical competence may be limited.[7] The design of the learning experience around the AI tool—the nature of the tasks assigned, the questions posed for reflection, the structure of mentor discussions—is paramount.

One of the most significant "new pathways" illuminated by AI is its potential to provide scalable and personalized practice and feedback opportunities for foundational teaching skills.[1] Traditional teacher education programs, often

constrained by resources and the logistics of practicum placements, can struggle to provide consistent, individualized, and frequent feedback, especially on reflective practice.[2] AI-powered simulators[13] and AI feedback tools[36] can offer what has been termed "unlimited do-overs" and consistent, data-informed feedback, which is difficult to achieve at scale with human mentors alone. This capacity for scalable, personalized support for practice and reflection represents a key affordance of AI for transforming PST development.

Furthermore, the integration of AI into TPD necessitates a re-evaluation of how PST competence is assessed. If PSTs are co-creating lesson plans with AI or using AI to analyze their teaching, assessment methods must evolve. The focus may need to shift from solely evaluating the final product (e.g., the lesson plan itself) to assessing the PST's process of using AI critically, ethically, and pedagogically. This includes their ability to effectively prompt AI tools, critically evaluate the outputs, make sound pedagogical modifications, and reflect meaningfully on AI-generated feedback. This implies a need to develop new frameworks and rubrics for assessing AI-TPACK in action.[1]

This comparative analysis underscores that AI-supported TPD is not a replacement for traditional methods but offers a powerful augmentation, creating new pathways that can be more personalized, practice-oriented, and scalable, provided its integration is thoughtful and pedagogically sound.

6   Implications and Recommendations for Future Practice and Research

The insights gleaned from the case study and the broader literature carry significant implications for the future of teacher education, policy, and research in the age of AI. To effectively harness AI's potential to create new and impactful professional development pathways for pre-service teachers (PSTs), a concerted effort is required across these domains.

6.1   Transforming Teacher Education Curricula: Integrating AI Literacy and Pedagogies

Teacher education programs stand at the forefront of preparing the next generation of educators and must proactively adapt their curricula to the realities of an AI-suffused educational landscape. This involves more than simply adding a technology course; it requires a deep and thoughtful integration of AI literacy and AI-related pedagogies across the curriculum. Specific recommendations include:

Developing AI Literacy and AI-TPACK: Curricula should explicitly aim to develop PSTs' AI literacy, encompassing an understanding of AI's capabilities, limitations, and societal implications, alongside fostering their AI-TPACK.[9] This could involve dedicated modules or, preferably, the integration of AI concepts and tools within existing methods courses, allowing PSTs to explore AI in subject-specific contexts.

Training in Prompt Engineering: Given that the effectiveness of many generative AI tools hinges on the quality of user prompts, PSTs need explicit training and practice in prompt engineering for various educational applications, from lesson planning to generating assessment items.[14]

Emphasis on Critical Evaluation: A core component of AI literacy is the ability to critically evaluate AI-generated content and the functionality of AI tools themselves.[7] PSTs must be taught to question AI outputs, check for bias, assess pedagogical soundness, and understand when and how to override or adapt AI suggestions.

Scenario-Based and Collaborative Learning: Teacher education programs should employ scenario-based learning activities where PSTs can apply AI tools to realistic teaching challenges and collaboratively explore strategies for effective integration. Working in groups can facilitate shared learning, problem-solving, and the development of a collective understanding of AI's role.[14]

Prioritizing Ethical Considerations: Ethical dimensions of AI use must be a central thread throughout the curriculum. This includes in-depth discussions and case studies on data privacy, algorithmic bias and its potential to exacerbate inequities, issues of intellectual property and plagiarism with AI-generated content, and the principles of responsible and equitable AI use in educational settings.[1]

A crucial underlying factor is that teacher education programs must themselves model the critical and ethical use of AI. This necessitates professional development for teacher educators to ensure they possess the knowledge and skills to effectively guide PSTs in navigating the complexities of AI in education.[5] Without this "train the trainers" approach, efforts to prepare PSTs may fall short.

Table 3: Comparative Analysis: Traditional vs. AI-Supported TPD for Pre-service Teachers in Lesson Planning & Reflection

Aspect of TPD	Traditional TPD Approaches for PSTs	AI-Supported TPD Approaches (Examples from Case Study)	Potential Advantages of AI	Potential Challenges of AI
Feedback on Planning	Mentor review of plans, peer feedback sessions; often delayed.	AI tools (e.g., Eduaide.ai) provide instant (though sometimes generic) suggestions for structure, activities, resources.	Immediate feedback, idea generation, identification of potential gaps.	Output may lack pedagogical depth, risk of uncritical acceptance, requires prompt engineering skills.
Skill Practice (Lesson Delivery)	Limited practicum opportunities, specific case study; but relevant literature); micro-teaching with peer/mentor feedback.	AI simulators for practice[13] (not in this environment to experiment; mock-teaching followed by AI-assisted reflection (e.g., MirrorTalk).	Scalable practice, "do-overs," safe environment to experiment. Structured reflection on practice.	Authenticity of simulations; quality of AI reflection prompts; translating reflection to action.
Reflection Methods	Journaling, written reports, mentor conferences; can be subjective or infrequent.[21]	AI-prompted spoken reflection (MirrorTalk), AI analysis of teaching data (e.g., talk time, questioning patterns from other tools[36]).	Structured prompts, potential for objective data, immediate reflection, making thinking visible.	Ensuring depth beyond surface-level, accuracy of AI analysis, PST engagement with feedback.
Personalization	Often standardized curriculum; mentor attempts to personalize support.	AI can tailor content suggestions (Eduaide.ai), reflection prompts can adapt (potentially), learning paths can be individualized.[1]	Addresses individual PST needs and pace more readily.	Requires sophisticated AI and careful design to be truly personalized pedagogically.
Scalability	Heavily reliant on human resources (mentors, supervisors), limiting individualized attention.	AI tools can support many PSTs simultaneously; automated feedback reduces some human workload.[13]	Cost-effective for providing certain types of support at scale.	Cannot replace nuanced human mentorship; risk of depersonalization if not balanced.
Development of Critical Skills	Relies on mentor guidance, course readings, and peer discussions to foster critical thinking about pedagogy.	Requires PSTs to critically evaluate AI outputs, refine prompts, adapt suggestions. Reflection on AI use itself builds critical AI literacy.	Opportunities to practice critical evaluation of technology; developing prompt literacy.	Risk of passive acceptance of AI suggestions if not scaffolded; AI may not inherently teach critical pedagogy.

6.2   Policy Considerations for Supporting AI in Teacher Professional Development

Educational institutions and policymakers play a vital role in creating an enabling environment for the effective integration of AI into TPD. Key policy considerations include:

Investment and Infrastructure: Adequate investment is needed in robust AI tools, reliable technological infrastructure within teacher education institutions and partner schools, and ongoing technical support.

Professional Development for Teacher Educators: Policies should support and fund professional development initiatives specifically designed for teacher educators to build their own AI literacy and pedagogical expertise in using AI for teacher training.

Ethical Guidelines and Frameworks: Clear, comprehensive guidelines and ethical frameworks for the use of AI in schools and teacher preparation programs must be developed and disseminated. These should address issues of data security, student privacy, algorithmic transparency, and equity.[6]

Support for Research and Innovation: Policies should encourage and fund research into the effective and ethical use of AI in teacher education, fostering a culture of evidence-based innovation.

6.3   Future Research Directions in AI for Pre-service Teacher Education

While this case study provides valuable insights, the field is dynamic and requires ongoing inquiry. Future research should explore several key areas:

Longitudinal Impact Studies: There is a need for longitudinal studies that track PSTs who have experienced AI-integrated TPD into their early careers to assess the long-term impact on their teaching effectiveness, pedagogical approaches, and retention in the profession.

Impact on Student Learning Outcomes: Rigorous research is required to investigate the downstream effects of AI-assisted TPD for PSTs on the learning outcomes and engagement of their future K-12 students.

Comparative Studies of AI Tools and Pedagogies: Further comparative studies are needed to evaluate the relative effectiveness of different AI tools (e.g., various lesson planners, reflection aids, or simulators) and different pedagogical approaches to integrating these tools into PST education.

Development and Assessment of AI-TPACK: More research is needed to refine conceptualizations of AI-TPACK and to develop valid and reliable instruments and methods for assessing its development in PSTs.[25]

AI for Equity and Diverse Learners: Future studies should specifically examine how PSTs can be trained to use AI tools to effectively support diverse learners, promote inclusive classroom environments, and address educational inequities.

Understanding PSTs' Ethical Reasoning: Research exploring how PSTs develop ethical reasoning regarding AI use, and the most effective ways to foster this development, is crucial.

7   Conclusion

7.1   Synthesizing the Journey: New Pathways Forged by AI in Teacher Development

The integration of Artificial Intelligence into the fabric of education is no longer a futuristic projection but a present-day reality, prompting a critical re-evaluation of how we prepare teachers for their complex roles. This paper has argued, through a synthesized case study and review of extant literature, that AI offers significant and novel pathways for the professional development of pre-service teachers, particularly in the foundational domains of lesson planning and teaching reflection. The journey of PSTs engaging with AI tools like Eduaide.ai and MirrorTalk, as depicted in the case study, reveals a landscape rich with potential. Benefits such as enhanced efficiency in planning, the spark of creative instructional ideas, and the facilitation of more structured, data-informed, and articulated reflection are tangible. PSTs found that AI could serve as a valuable assistant, reducing cognitive load in some areas and providing new perspectives.

However, this journey is also marked by notable challenges. The variable quality of AI outputs necessitates a high degree of critical engagement and pedagogical discernment from PSTs. The development of prompt engineering skills, the navigation of ethical considerations surrounding AI use, and the leap from using AI for superficial task completion to deep pedagogical integration are all significant hurdles. The risk of over-reliance and the need to continually assert human pedagogical judgment in an AI-assisted environment are central tensions that emerged.

7.2   Concluding Thoughts on the Future of AI in Shaping Reflective Practitioners

Looking forward, the role of AI in teacher education will undoubtedly continue to evolve. The "new pathways" discussed are not merely about adopting new technologies; they are about fundamentally rethinking how we support PSTs in becoming competent, critical, and reflective practitioners. A human–centered approach must remain paramount, where AI serves to augment and empower human capabilities, not replace them. The goal is to leverage AI to help PSTs develop deeper pedagogical understanding, more refined practical skills, and a robust capacity for ongoing professional learning.

The ultimate aim of these AI-enhanced pathways should be to cultivate a mindset of continuous learning and adaptation in PSTs. The specific AI tools available today will inevitably change and be superseded by new innovations. Therefore, the most crucial outcome of integrating AI into teacher professional development is not mastery of current tools, but the cultivation of enduring AI literacy, strong ethical frameworks, and a reflective, adaptive stance that will enable future teachers to engage with any AI innovation critically, thoughtfully, and effectively. As AI continues to shape the contours of teaching and learning, ongoing research, careful pedagogical integration, and unwavering ethical vigilance will be essential to ensure that these new pathways lead to a more effective, equitable, and humanistic educational future.

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Editor *Changkui LI wtocom@gmail.com*