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Integrating AI-TPACK for Pre-Service Teachers: Applications and Challenges in English Language Program

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Abstrak

Artificial Intelligence (AI) mentransformasi pendidikan dengan menawarkan berbagai peluang inovatif untuk meningkatkan proses pengajaran dan pembelajaran. Integrasi AI ke dalam kerangka *Technological Pedagogical Content Knowledge* (TPACK) telah menghasilkan pengembangan AI-TPACK, yang menekankan keterampilan dan strategi khusus yang diperlukan untuk mengintegrasikan AI secara efektif dalam konteks pendidikan. Meskipun penelitian yang ada sebagian besar berfokus pada kesiapan guru dalam mengadopsi AI, perhatian terhadap calon guru (*pre-service teachers* / PSTs) dan penerapan praktis AI-TPACK oleh mereka masih terbatas. Penelitian ini mengeksplorasi bagaimana PSTs dalam Program Pendidikan Bahasa Inggris menerapkan AI-TPACK dalam praktik pengajaran mereka serta mengkaji tantangan yang mereka hadapi selama proses implementasi. Penelitian ini menggunakan pendekatan *narrative inquiry*, dengan pengumpulan data melalui kuesioner, wawancara semi-terstruktur, dan jurnal reflektif. Kuesioner digunakan untuk menilai pemahaman teoretis dan praktis PSTs terhadap AI-TPACK, sementara wawancara memberikan wawasan mendalam mengenai pengalaman nyata serta tantangan yang mereka hadapi. Jurnal reflektif digunakan untuk menangkap refleksi berkelanjutan para peserta, yang mendokumentasikan perkembangan perspektif dan keterampilan mereka dari waktu ke waktu. Analisis tematik digunakan untuk melakukan triangulasi data dari berbagai sumber tersebut guna memperoleh pemahaman yang komprehensif mengenai kompetensi dan tantangan PSTs dalam menerapkan AI-TPACK. Hasil penelitian menunjukkan bahwa AI-TPACK meningkatkan kemampuan PSTs dalam merancang pembelajaran, menyesuaikan metode pengajaran, serta menciptakan pengalaman belajar yang lebih menarik dan interaktif. Penggunaan alat berbasis AI juga memungkinkan pembelajaran yang lebih personal dengan menyesuaikan materi dan kecepatan pembelajaran sesuai kebutuhan siswa, sehingga meningkatkan efisiensi pengajaran sekaligus hasil belajar siswa.

Kata Kunci: AI-TPACK; pre-service teachers; technological pedagogical content

Abstract

Artificial Intelligence (AI) is transforming education, offering innovative opportunities to enhance teaching and learning. Integrating AI into the Technological Pedagogical Content Knowledge (TPACK) framework has led to the development of AI-TPACK, which addresses the specific skills and strategies required for effective AI integration in educational contexts. While existing research focuses primarily on teachers' readiness to adopt AI, limited attention has been given to pre-service teachers (PSTs) and their practical application of AI-TPACK. This study explores how PSTs in an English Language Program apply AI-TPACK in their teaching practices and investigates the challenges they encounter during implementation. Employing a narrative inquiry approach, the study collects data through questionnaires, semi-structured interviews, and reflective journals. Questionnaires assess PSTs' theoretical and practical understanding of AI-TPACK, while interviews provide in-depth insights into their lived experiences and challenges. Reflective journals capture ongoing reflections, documenting their evolving perspectives and skills. Thematic analysis is used to triangulate data across

these sources, ensuring a robust understanding of PSTs' competencies and challenges in applying AI-TPACK. The findings indicate that AI-TPACK improves PSTs' ability to design lessons, adjust teaching methods, and create more engaging and interactive learning experiences. AI tools also enable more personalized learning by modifying content and adjusting the speed of instruction to meet individual student needs, enhancing both teaching efficiency and student outcomes.

***Keywords**: AI-TPACK, Pre-Service Teachers, Technological Pedagogical Content*

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Introduction

Artificial intelligence (AI) has rapidly advanced, significantly impacting various sectors, including education. Integrating AI into teaching and learning offers immense potential to enhance educational experiences (Celik, 2023; Deng & Zhang, 2023; Ning et al., 2024). The advent of generative AI tools has considerably accelerated AI's influence on education, eliciting a range of responses from educators (Karataş et al., 2024; Mishra et al., 2023). This rapid integration of AI underscores the necessity for a robust theoretical framework to guide the effective incorporation of these tools into educational practices (K. Wang et al., 2024). The Technological Pedagogical Content Knowledge (TPACK) framework, introduced by Mishra & Koehler (2006) combines technology, pedagogy, and content knowledge, provides a strong foundation for incorporating AI in education. The AI-TPACK model builds on this by adding AI-specific tools and strategies, creating new opportunities for innovation and personalized learning (Casal-Otero et al., 2023). However, effectively integrating AI into education requires addressing challenges such as understanding how to apply AI in meaningful and practical ways and evaluating its impact on teaching and learning outcomes.

These challenges are particularly significant in teacher education, where PSTs are still developing the necessary skills to integrate technology into their teaching practices (Sun et al., 2023). They often face hurdles such as limited classroom experience, a need for technological proficiency, and the necessity of understanding the application of AI-TPACK to enhance their teaching strategies (Kandlhofer et al., 2023; Valtonen et al., 2020a). Addressing these challenges is crucial for equipping PSTs with the competencies needed to effectively integrate AI-TPACK into their educational practices. Many studies have discussed the integration of AI-TPACK in teaching, with the majority focusing on assessing the readiness of educators to incorporate AI into their teaching practices (Karataş & Ataç, 2024; Ning et al., 2024). These studies have provided valuable insights into the varying proficiency levels of educators across different TPACK components (Karataş & Ataç, 2024). However, despite these advancements, most studies have centered on the overall readiness of teachers to adopt AI tools, leaving a notable gap in the research regarding the application of AI-TPACK by PSTs., It is therefore essential to explore how PSTs apply AI-TPACK in real classroom settings, as well as the challenges they encounter during its implementation to provide a comprehensive view of their experiences (Celik, 2023; Lorenz & Romeike, 2023; Swallow & Olofson, 2017). This exploration is crucial not only for enhancing teaching strategies but also for fostering the professional growth of future educators, ensuring they are well-prepared to navigate the complexities of integrating AI into their pedagogy (Chen et al., 2023; Rosenberg & Koehler, 2015; Valtonen et al., 2020b).

This research aims to bridge the gap by examining how PSTs apply AI-TPACK in their teaching practices and exploring the challenges they encounter during this process. Specifically, it seeks to investigate how PSTs integrate AI-TPACK into their teaching practices during their training, and identify the challenges and barriers faced in real classroom scenarios. Additionally, the study aims to provide actionable insights and recommendations to enhance AI-TPACK training programs for future educators. By focusing on both the application of AI-TPACK and challenges faced by PSTs, this research aims

to contribute valuable insights that can inform the development of more effective training curricula and support the successful integration of AI-TPACK in educational settings.

Integration of AI to TPACK

The integration of AI into teaching practices can be understood through the lens of the TPACK framework, which emphasizes the interconnectedness of technology, pedagogy, and content knowledge in effective teaching (Backfisch et al., 2024; Yeh et al., 2021). As Mishra and Koehler (2006) first introduced, TPACK focuses on the need for educators to balance these three components to successfully incorporate technology into their teaching. In the context of AI, AI tools are considered part of the technological knowledge (TK) aspect, while their impact on teaching strategies and content delivery affects pedagogical content knowledge (PCK) and content knowledge (CK) (Nurwahidah et al., 2023; Usman et al., 2024). For example, AI technologies can enhance content delivery by personalizing lessons to cater to the unique needs of individual students, a key aspect of AI-TPACK integration (Kusuma et al., 2023). AI tools can also assist in automating administrative tasks such as grading and providing real-time feedback, thereby improving teaching efficiency and allowing for more time to focus on instructional planning (Karataş & Ataç, 2024; Sun et al., 2023)

Moreover, AI-TPACK presents opportunities for PSTs to apply AI in ways that align with TPACK's goals of integrating technology meaningfully into teaching practices. AI can support personalized learning by adjusting content and pacing to suit individual students (Drajati et al., 2018; Karataş & Ataç, 2024). It extends the possibilities for engaging students in a way that traditional tools may not (Sari et al., 2021). Additionally, AI tools can offer real-time assessments, which help to refine the pedagogical approach while enhancing students' content knowledge (Martin et al., 2024; W. Wang et al., 2018). However, despite its potential, integrating AI into educational practices poses challenges, particularly in terms of adequate teacher training and ongoing professional development (Kusuma et al., 2023; Mishra & Koehler, 2006; Schmidt et al., 2009). Teachers often struggle to find the balance between traditional teaching methods and the incorporation of AI, which is where continuous training and support become critical (Ning et al., 2024). Thus, the integration of AI into TPACK requires not only understanding how technology can enhance pedagogical and content knowledge but also addressing challenges related to training, technology access, and the adaptation of teaching methods (Backfisch et al., 2023; Ning et al., 2024; Sofyan et al., 2023).

AI-TPACK Framework

Recent research, such as that of Ning et al. (2024), demonstrates that these studies have proposed various framework models, which, despite having different names, essentially convey the same underlying concepts. The figure highlights the variety of AI-TPACK frameworks, while also emphasizing their common foundational principles. When considering the integration of AI into TPACK for PSTs, these frameworks stress the essential skills required to manage and interact with AI technologies (AI-TK), evaluate their potential and limitations (AI-TPK), and apply them to specific subject areas (AI-TCK) (Ning et al., 2024). For PSTs, implementing AI-TPACK involves navigating the complexities of incorporating AI into teaching while maintaining a balance with traditional TPACK. This integration often presents challenges, such as adjusting to new technologies, aligning AI tools with teaching objectives, and ensuring students remain meaningfully engaged (Karataş & Ataç, 2024; Ning et al., 2024). These challenges highlight the importance of providing targeted support and professional development to effectively implement AI-TPACK and fully harness its potential in educational settings (Karataş et al., 2024).

Method

This study employed narrative inquiry to explore the application and challenge of AI-TPACK integration by PSTs. Narrative inquiry focuses on understanding the lived experiences and personal stories of individuals, providing rich insights into their practices and challenge (Barkhuizen et al., 2025).

Participants

The participants were PSTs in a teacher education program. A purposive sampling technique was employed to ensure that the participants chosen had specific characteristics relevant to the study (Patton, 2015). The

researcher identified 15 PSTs from a teacher education program known to incorporate AI-TPACK. This process involved collaboration with program coordinators to pinpoint candidates who had engaged with AI-TPACK. This approach allowed for the selection of individuals who had exposure to AI-TPACK during their training, ensuring that they possessed the necessary background to provide valuable insights into the application and challenge on AI-TPACK integration.

Data Collection

The data collection process in this study involved a combination of questionnaires, semi-structured interviews, and reflective journals. Questionnaires were designed to assess the theoretical and practical understanding of AI-TPACK among PSTs. These included Likert-scale questions that evaluate knowledge across the TPACK components and their integration with AI tools. Additionally, scenarios were presented where PSTs described how they would apply AI-TPACK in various teaching contexts, helping to identify any gaps in their understanding. Semi-structured interviews were conducted to provide deeper insights into PSTs' experiences and reflections regarding the implementation of AI-TPACK.The interview questions were developed based on the AI-TPACK framework.. The interview guide included questions that cover key components of AI-TPACK. An interview guide will be developed with open-ended questions to encourage detailed responses, such as describing experiences, challenges faced, and reflective practices. Interviews were recorded with consent to ensure accurate transcription and thorough analysis. Reflective journals will be collected from PSTs over a period of time to capture their ongoing reflections on the application of AI-TPACK. Prompts guided these reflections, encouraging documentation of experiences, challenges, and insights related to the integration of AI-TPACK in teaching. Regular entries helped in documenting the development of their understanding and skills. Analysis of these journals will reveal common themes, insights, and areas for further exploration.

Data Analysis

The data analysis for this study involved multiple steps to ensure a comprehensive understanding of PSTs competencies in applying AI-TPACK. By triangulating data from questionnaires, semi-structured interviews, and reflective journals, the research ensured robust and reliable findings. This method allows for cross-verification of information, where the strengths of each data source complement and validate the others. The questionnaire data were analyzed to assess PSTs' theoretical and practical understanding of AI-TPACK, identifying their knowledge and application skills across the AI-TPACK components. Semi-structured interviews were transcribed and analyzed thematically, with coding processes identifying key themes and patterns to gain in-depth qualitative insights into PSTs' experiences and challenges with AI-TPACK integration. Reflective journals underwent thematic analysis to capture ongoing reflections and identify trends over time.

The integrated analysis of these data sources provided a holistic view of PSTs' knowledge, application, and challenges regarding AI-TPACK. This multi-method approach contributed valuable insights into the practical experiences of PSTs, ultimately guiding the development of targeted training programs and support mechanisms to enhance their ability to effectively implement AI-TPACK in an English Language Program. By focusing on qualitative data through triangulation, the study ensured that the findings are robust, reliable, and provide a comprehensive understanding of PSTs' competencies and areas needing improvement.

Results and Discussion

Results

Based on the data analysis from the questionnaires, interviews, and reflective journals, several key insights emerged regarding the application and challenges of AI-TPACK among PSTs. The data reveal how AI tools were integrated into teaching practices, particularly in enhancing content knowledge, pedagogical strategies, and classroom management. Additionally, the findings highlight the challenges PSTs face in implementing AI-TPACK, ranging from technological limitations to pedagogical concerns and contextual factors. These insights provide a comprehensive understanding of how AI-TPACK supports or hinders effective teaching practices in English language programs.

Application of AI-TPACK in Teaching Practices

The application of AI-TPACK in teaching practices has emerged as a key focus for PSTs, as they integrate technology to enhance their instructional methods. Based on the data from questionnaires, interviews, and reflective journals, this section explores how PSTs apply AI-TPACK in their classrooms, examining its impact on content knowledge, pedagogical strategies, and overall teaching effectiveness.

Table 1. The Analysis of Questionnaire

Construct	Number of Items	Mean	SD
Content Knowledge (CK)	5	4.2	0.67
Pedagogical Content Knowledge (PCK)	6	4.1	0.75
AI-Technological Content Knowledge (AI-TCK)	6	4.0	0.76
AI-Technological Pedagogical Knowledge (AI-TPK)	6	3.9	0.79
AI-Technological Content Knowledge (AI-TPACK)	5	4.1	0.71

Construct	**Number of Items**	**Mean**	**SD**	**Interpretation**
Content Knowledge (CK)	5	4.2	0.67	High
Pedagogical Content Knowledge (PCK)	6	4.1	0.75	High
AI-Technological Content Knowledge (AI-TCK)	6	4.0	0.76	High
AI-Technological Pedagogical Knowledge (AI-TPK)	6	3.9	0.79	High
AI-Technological Content Knowledge (AI-TPACK)	5	4.1	0.71	High

The table analyzes the impact of AI-TPACK on PSTs, focusing on five key areas: CK, PCK, AI- AI-TCK, AI-TPK, and AI-TPACK. The findings suggest that AI-TPACK positively affects all these areas. PSTs reported strong CK with a mean score of 4.2, showing that AI-TPACK helps build a solid foundation in content understanding. The PCK score of 4.1 indicates that AI-TPACK boosts PSTs' confidence in adapting teaching strategies. With a mean of 4.0, AI-TCK highlights how AI supports subject knowledge, while AI-TPK, with a score of 3.9, suggests AI tools help with classroom management and student motivation, though responses varied more in this area. Finally, the AI-TPACK score of 4.1 indicates that AI-TPACK aids in creating engaging and efficient teaching.

Key findings show that AI-TPACK enhances engagement by creating interactive learning environments, improves teaching efficiency through better lesson design, and motivates both PSTs and students with innovative teaching strategies. Overall, AI-TPACK proves beneficial in all areas, improving teaching practices and showing its potential to enhance teaching and learning outcomes. While some variability exists in AI-TPK, the overall results highlight AI-TPACK's significant contribution to teaching effectiveness, making it a valuable tool for pre-service teachers.

Additionally, the interview data revealed that PSTs apply AI-TPACK by using AI tools to personalize lessons and adapt teaching strategies to meet individual student needs. They integrate AI into lesson planning, particularly in teaching language skills such as reading, writing, and listening, and use AI to provide real-time feedback and monitor student progress. This application of AI-TPACK helps create more engaging and interactive learning experiences for students.

> Extract 1: *"In my classroom, I apply AI-TPACK by integrating AI tools to enhance both the content and pedagogical aspects of my lessons. For example, I use AI-powered language learning apps to personalize reading and writing exercises, tailoring them to the individual needs of students based on their proficiency levels. I also use AI tools to create interactive activities, such as quizzes and games, that help engage students in language practice, making learning more dynamic. In one instance, I used an AI-driven grammar checker to provide immediate feedback to students on their writing, allowing them to make real-time corrections. Additionally, I use AI to monitor student progress by tracking performance on various tasks, which helps me adjust my teaching strategies to better meet their needs. This integration of AI enhances both the content delivery and the overall learning experience in my classroom."*

The response highlights how PSTs apply AI-TPACK in their classrooms by using AI tools to personalize lessons and adapt teaching strategies. PSTs integrate AI into content delivery, such as using language learning apps to tailor reading and writing exercises, reflecting AI-TCK. They also create interactive activities, like quizzes and games, to engage students, demonstrating AI-TPK. Additionally, PSTs use AI tools for real-time feedback on student work and track progress, allowing for more effective teaching strategies and enhanced learning experiences, showcasing the application of AI-TPACK as a whole.

> Extract 2 : *"As a teacher, I have noticed significant changes in my teaching strategies and lesson planning since I started using AI tools. These tools have sparked creativity by providing fresh ideas and making my lessons more engaging and interactive. They have also saved me time by automating repetitive tasks like grading and attendance, allowing me to focus on crafting meaningful and effective lessons. AI has been incredibly helpful in supporting personalized learning, as it suggests tailored activities and adjusts pacing based on individual student needs. It has also improved my ability to provide constructive feedback through data-driven insights. Additionally, I feel that using AI has encouraged me to grow professionally, pushing me to adapt and embrace new teaching approaches. However, I also recognize the importance of maintaining a balance, ensuring that the use of AI doesn't overshadow the personal connections I have with my students."*

The integration of AI tools into teaching practices has led to significant changes in instructional strategies and lesson planning. These tools have enhanced creativity, providing innovative ideas that increase lesson engagement and interactivity. AI has also streamlined time-consuming tasks, such as grading and attendance, enabling educators to focus on developing more effective and meaningful lessons. Moreover, AI supports personalized learning by tailoring activities and adjusting pacing to meet individual student needs, while also offering data-driven insights that improve the ability to provide constructive feedback. The adoption of AI encourages professional growth, prompting educators to explore and embrace new pedagogical approaches. However, there is a recognition of the importance of maintaining a balance, ensuring that AI does not diminish the vital personal connections between teachers and students.

The Challenges of Implementing AI TPACK

PSTs may encounter several challenges when integrating AI-TPACK into their teaching practices. The challenges of implementing AI-TPACK can stem from various factors.

> Extract 3 *:" AI technologies have greatly enhanced my teaching practice by offering personalized learning, automating administrative tasks, and improving lesson planning. While these tools help me provide data-driven feedback and engage students more effectively, I also recognize the challenge of maintaining a balance between technology and the essential human connection in teaching."*

To support the integration of AI tools in education, it is essential to recognize both their advantages and challenges. AI technologies can enhance personalized learning, streamline administrative tasks, and improve student engagement. However, concerns about data privacy, potential biases, and the need for teacher training remain. Balancing these benefits and challenges is crucial for effective implementation.

AI technologies in teaching English hold significant potential to enhance both teaching and

learning. AI can provide personalized learning experiences by adapting to the individual needs of students, offering created content, and adjusting the pace of learning. This can be especially valuable in helping students improve specific language skills such as reading, writing, listening, and speaking. AI tools can also support teachers by automating administrative tasks like grading and feedback, allowing more time for instructional planning and student interaction.

> Extract 4 : *"I see AI technologies in teaching English have great potential to enhance learning by personalizing content and adjusting the pace for individual students. These tools also help me automate tasks like grading, allowing more time for instruction. However, AI cannot replace the human connection crucial to teaching and can sometimes be biased based on the data it uses. Accessibility issues, such as unequal access to technology, are also a concern. Additionally, keeping up with the rapid development of AI requires ongoing training, which can be challenging."*

It implied how AI can personalize learning by adjusting content and pace to meet individual student needs, improving the overall learning experience. AI tools also helped automate tasks like grading, giving teachers more time for instructional activities. However, the statement highlighted that AI cannot replace the essential human connection in teaching and may be influenced by biases in its data. Additionally, challenges such as unequal access to technology and the need for continuous teacher training in AI tools are noted.

> Extract 5 : *"AI tools have influenced my teaching strategies and lesson planning by enabling more personalized and efficient approaches. They allow me to create lessons to individual student needs, adjusting content and adjusting based on real-time data. AI tools have supported a more student-centered approach, enhancing both the quality and efficiency of my lesson planning."*

> Extract 6 : *"I get challenges in integrating AI-TPACK, including limited access to reliable technology, insufficient training, and difficulty balancing traditional teaching methods with AI tools. I sometimes struggle to fully understand how to apply AI in my classroom and feel overwhelmed by the rapid pace of technological change. To address these challenges, I believe ongoing professional development and hands-on experience with AI tools are crucial. Collaborating with peers and seeking support from educational technology experts can also help me overcome these barriers and improve my use of AI-TPACK."*

AI tools have significantly influenced teaching strategies and lesson planning by enabling personalized learning experiences and automating administrative tasks, which allows teachers to focus more on creating engaging content. These tools help create lessons to individual student needs and provide real-time adjustments based on data. However, challenges in integrating AI-TPACK include limited access to technology, insufficient training, and the difficulty of balancing traditional teaching methods with new AI tools. To overcome these barriers, ongoing professional development, hands-on experience with AI tools, and peer collaboration are essential. Overall, while AI has the potential to enhance teaching, it requires careful integration and support to address these challenges effectively.

Discussion

The integration of AI-TPACK into the teaching practices of PSTs has demonstrated benefits in enhancing instructional effectiveness (Celik, 2023; Mishra et al., 2023). Based on data from questionnaires, interviews, and reflective journals, it was clear that AI-TPACK facilitates the personalization of lessons, the adaptation of content delivery, and the creation of interactive learning experiences. PSTs had reported using AI tools to create lessons to individual student needs, particularly in areas such as reading, writing, and listening. AI also helped in providing real-time feedback, monitoring student progress, and fostering student engagement through interactive activities such as quizzes and games. This approach reflected the synergy between technology, pedagogy, and content knowledge, where AI tools are effectively integrated into the teaching process to enhance CK, PCK, and AI-TCK (Mishra & Koehler, 2006). These findings underscored the potential of AI-TPACK to promote a student-centered, engaging, and

efficient approach to English language teaching (Celik, 2023; Wang et al., 2024).

Despite the positive impact of AI-TPACK, PSTs had several challenges in integrating these technologies into their teaching practices. A primary barrier was insufficient training. Many PSTs report that their teacher education programs did not provide adequate preparation in using AI tools effectively, leaving them uncertain about how to integrate these tools with traditional teaching methods. This lack of training often results in difficulties in adapting their teaching strategies to fully leverage AI for personalized learning, making it challenging to implement AI-TPACK seamlessly (Deng & Zhang, 2023; K. Wang et al., 2024).

Additionally, the rapid pace of technological change and the limited access to AI resources can further hinder the effective implementation of AI-TPACK in English language programs. To address these challenges, ongoing professional development, hands-on experience with AI tools, and collaboration with peers are essential. By integrating AI training into teacher education programs and providing practical, real-world experience, pre-service teachers can develop the necessary skills to incorporate AI-TPACK effectively into their teaching practices (Casal-Otero et al., 2023).

The integration of AI-TPACK into PSTs' teaching practices has shown clear benefits in enhancing instructional effectiveness (Celik, 2023; Mishra et al., 2023). Findings from questionnaires, interviews, and reflective journals indicate that AI-TPACK supports lesson personalization, adaptive content delivery, and interactive learning. PSTs reported using AI tools to tailor instruction to students' needs, particularly in reading, writing, and listening. AI also enabled real-time feedback, progress monitoring, and increased engagement through interactive activities such as quizzes and games. These practices reflect the synergy between technology, pedagogy, and content knowledge, where AI integration enhances CK, PCK, and AI-TCK (Mishra & Koehler, 2006). Overall, AI-TPACK promotes a more student-centered and effective approach to English language teaching (Celik, 2023; Wang et al., 2024).

Despite these benefits, several challenges were identified. A key barrier was insufficient training, as many PSTs reported limited preparation in using AI tools within their teacher education programs. This lack of preparation led to uncertainty in integrating AI with existing pedagogical practices, hindering effective implementation (Deng & Zhang, 2023; Wang et al., 2024). In addition, PSTs often relied on trial-and-error approaches when using AI tools, which reduced instructional efficiency and confidence. Some participants also expressed difficulty in aligning AI-generated outputs with pedagogical objectives, indicating gaps in pedagogical decision-making. These challenges suggest that without structured guidance, the potential of AI-TPACK may not be fully realized in classroom practice (Chen et al., 2023).

Moreover, rapid technological changes and limited access to AI resources further constrained implementation. Variations in institutional support and infrastructure also influenced PSTs' ability to experiment with AI tools effectively. In some cases, limited access to stable internet or premium AI features restricted the depth of integration in teaching activities. To address these challenges, ongoing professional development, hands-on experience with AI tools, and peer collaboration are essential. Integrating AI-focused training into teacher education programs and providing practical learning opportunities are necessary to support PSTs in applying AI-TPACK effectively (Casal-Otero et al., 2023).

Conclusion

This study has investigated how PSTs implement AI-TPACK in their teaching practices and the challenges they encounter when incorporating AI tools into English language programs. The findings highlight that AI-TPACK improves PSTs' ability to design lessons, adjust teaching methods, and create more engaging and interactive learning experiences. AI tools also enable more personalized learning by modifying content and adjusting the pace of instruction to meet individual student needs, enhancing both teaching efficiency and student outcomes. However, challenges such as insufficient training, limited access to resources, and the rapid pace of technological advancements hinder the full integration of AI-TPACK. To address these issues, ongoing professional development, practical training, and stronger institutional

support are essential for fully leveraging AI tools in English language teaching. Future studies could focus on the long-term effects of AI-TPACK on teaching practices as PSTs become established educators. Research could also explore the impact of various AI tools on student learning outcomes in English language programs, comparing their effectiveness in different educational contexts. Additionally, further research could examine the most effective types of training and professional development programs to equip PSTs with the skills needed to integrate AI-TPACK effectively. Investigating the application of AI-TPACK in diverse educational settings, including those with limited technological resources, could provide insights into how its use might vary across different environments. Finally, future research could explore the ethical concerns surrounding AI in education, particularly with regard to data privacy and potential biases in AI algorithms, ensuring that AI integration is ethical and equitable.

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