Enhancing Novice EFL Teachers' Competency in AI-Powered Tools Through a TPACK-Based Professional Development Program

Hajjah Zulianti[1], Hastuti[2], Eva Nurchurifiani[1], Tommy Hastomo[1,3], Aksendro Maximilian[1], Galuh Dwi Ajeng[1]

[1] English Education Program, STKIP PGRI Bandar Lampung, Lampung, Indonesia

[2] Indonesian Education Program, STKIP PGRI Bandar Lampung, Lampung, Indonesia

[3] English Language Education, Universitas Negeri Malang, Jawa Timur, Indonesia

Correspondence: Hajjah Zulianti, English Education Program, STKIP PGRI Bandar Lampung, Lampung, Indonesia. E-mail: hazaulie@gmail.com

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Abstract

As artificial intelligence (AI) continues to advance rapidly, its application in educational settings is increasingly expanding. However, a substantial gap persists in the number of novice English as a Foreign Language (EFL) teachers who are well-prepared to integrate technology in learning activities. This research created a professional development (PD) program grounded in the technological pedagogical content knowledge (TPACK) framework to tackle this issue and enhance the AI-related teaching skills of novice EFL teachers. The study employed a quasi-experimental design, with 20 participants in the experimental group and 20 in the control group, to assess the impact of the PD program on various aspects of AI teaching competence, including AI-powered tools knowledge test, teaching skills related to AI-powered tools, and AI-powered tools teaching self-efficacy. The research utilized several instruments, such as AI-powered tools self-efficacy scale, a rubric for evaluating AI-powered tools lesson plans, an AI-powered tools knowledge test, and semi-structured interviews. The findings demonstrated that the TPACK-based PD program a) enhanced the AI-powered tools knowledge of novice EFL teachers, b) improved their ability to integrate AI-powered tools into their teaching practices, and c) boosted their self-efficacy in teaching with AI-powered tools. These results underscore the impact of this program for bolstering novice EFL teachers' proficiency in using AI-powered tools and provide valuable insights for the development of effective PD programs for EFL educators.

Keywords: AI-powered tools, novice EFL teachers, professional development program, TPACK

1. Introduction

Educators and teacher candidates often encounter difficulties in conveying abstract ideas or complex phenomena that are not easily observed in daily life when teaching through traditional methods like textbooks and chalkboards. To address these challenges, students are typically guided to engage in practical activities or utilize visual aids and models to deepen their understanding. However, these strategies can sometimes increase the cognitive load on students, especially those who already find it challenging to comprehend such concepts (Na & Jang, 2016). In this context, technology plays a crucial role by allowing learners to engage with content in an engaging and immersive manner, reducing the cognitive load they might otherwise experience.

Researchers have introduced various technologies into education as a way to tackle the many challenges educators encounter. Specifically, Information and Communication Technology (ICT) has become a highly effective means of simplifying complex concepts. For example, Flash-based programs can create interactive simulations for English language instruction, offering dynamic grammar exercises and improved text comprehension activities. These efforts have shown considerable promise in embedding technology into classroom learning, thereby boosting student comprehension and learning efficiency (Metaria & Cahyono, 2024). Consequently, researchers have conducted extensive studies to investigate strategies that effectively utilize technology to enhance teaching and learning outcomes. These studies primarily aim to uncover methods that fully leverage technology integration, resulting in more streamlined and impactful teaching practices (Torun, 2020; Yeh et al., 2021).

A substantial number of research studies have explored the integration of technology into classroom learning, a field traditionally led by teacher expertise. In 2006, Mishra and Koehler introduced the TPACK framework, which merges Pedagogical Content Knowledge (PCK) with Technological Knowledge (TK). In the same way that Pedagogical Content Knowledge (PCK) is cultivated through the integration of Pedagogical Knowledge (PK) and Content Knowledge (CK), the TPACK framework is derived from the intersection of PK, CK, and TK. This convergence not only enhances the development of PCK but also facilitates the formation of Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK) (Mishra & Koehler, 2006). The synergy among PCK, TPK, and TCK is essential to the construction of TPACK (Mishra, 2019; Schmid et al., 2020). The advancement of TPACK underscores the ability of future educators to seamlessly incorporate technology into their teaching while accommodating various content areas and learning needs (Hastomo et al., 2024). In 2019, Mishra expanded the TPACK model by introducing Contextual Knowledge (XK), recognizing the need

to understand the educational context in light of evolving classroom dynamics (Mishra, 2019). With the rapid progression of technology, research has increasingly concentrated on advancing TPACK among educators and prospective teachers across various disciplines.

Even with TPACK training, both aspiring and experienced teachers frequently find it challenging to incorporate technology into their classrooms seamlessly. Despite TPACK education being designed to equip educators with the essential knowledge and skills to integrate technology with instructional content and teaching contexts, many still face challenges in effectively implementing technology within learning environments (Cahyono et al., 2016). These challenges frequently stem from the technology's inherent design, which is typically geared toward industrial rather than educational applications, resulting in less effective utilization within educational contexts. Mastering the technology, choosing the appropriate tools, and developing compatible learning materials are essential components in successfully integrating technology into the classroom (Syamdianita & Cahyono, 2021).

For example, AI-powered tools can automatically generate essays or suggest grammar improvements. Although initially developed for professional and commercial purposes, these AI-powered tools can be repurposed for educational goals in English language learning, such as helping students enhance their writing skills or correct grammatical errors, provided its use is adapted to the learning context (Wulyani et al., 2024). Researchers conducted a study in Indonesia where AI-powered tools were introduced into English language teaching in schools (Hastomo et al., 2024). However, the integration of AI-powered tools in classrooms fell short of the anticipated success. This shortfall might be attributed to the constraints of these tools, which can hinder their applied use, even when teachers have received training in their use. While AI-powered tools can quickly provide feedback on student writing, few can effectively leverage it to improve their English language skills significantly. Therefore, even though prospective teachers are familiar with utilizing AI-powered tools, they often need to determine where in the curriculum the technology can be applied, design appropriate lessons, and effectively integrate AI-powered tools. The main challenge is in adapting technology not initially intended for education into classroom environments, making it more difficult for prospective teachers to fully comprehend and master the technology (Hastomo et al., 2024; Marzuki et al., 2023; Wulyani et al., 2024).

Technology is often utilized in educational settings in ways that mirror the use of traditional teaching tools due to inherent functional limitations that prevent them from being fully adapted to the dynamic nature of modern classrooms. In English language instruction, traditional classrooms typically rely on textbooks and chalkboards to teach grammar and vocabulary (Istiara & Hastomo, 2023). In contrast, contemporary classrooms may utilize smartboards, tablets, or other digital devices to convey the same content (Sutiyono et al., 2022). However, these technologies often function primarily as visual aids for teaching grammar or vocabulary rather than fundamentally transforming instructional methods.

Syamdianita and Cahyono (2021) conducted research focused on incorporating technology-based language learning strategies into the TPACK framework to overcome the functional constraints of traditional technologies. Unlike traditional technological tools, technology-based language learning applications enable educators to design more dynamic learning materials once they have mastered the application development environment. Although earlier text-based language learning applications posed challenges for learners, the emergence of visual and interactive applications has mitigated these difficulties in the learning process (Cahyono et al., 2016). Prospective teachers can easily grasp the application development process, allowing them to create instructional materials efficiently. On the other hand, traditional technologies are usually confined to certain functions, limiting their classroom flexibility. These technology-based applications address these challenges by enabling prospective teachers and educators to design learning materials that are specifically aligned with their instructional requirements. As a result, researchers have developed models and educational programs that incorporate this technology as a tool within the TPACK framework (Muslimin et al., 2023). Consistent with this research, Indonesia has launched professional development programs aimed at enhancing the skills of prospective teachers and educators in utilizing language learning technologies alongside the creation and implementation of new curricula.

In the ELT context, AI-powered tools have become increasingly essential, fueled by progress in deep learning and machine learning algorithms. These tools acquire the ability to process large volumes of linguistic data, make inferences, and recognize intricate linguistic patterns. The evolution of AI-powered tools has resulted in the development of numerous applications that greatly benefit English language learners, such as Grammarly for grammar correction, Quillbot for paraphrasing, ChatGPT for idea generation, and Jenni.AI for supporting academic writing (Marzuki et al., 2023; Wulyani et al., 2024). The expanding role of AI-powered tools in this area has notably transformed the English learning process. Within educational settings, these tools are utilized to analyze student learning patterns and provide personalized guidance through generative AI-powered tools, facilitating large-scale data analysis and addressing previously challenging issues (Algaraady & Mahyoob, 2023; Alkaissi & McFarlane, 2023; Casal & Kessler, 2023).

While previous research has examined the integration of technology into classroom learning through the TPACK framework (Cahyono et al., 2016; Hastomo et al., 2024; Mishra, 2019; Muslimin et al., 2023; Nazari et al., 2019, 2020; Nugroho et al., 2022; Syamdianita & Cahyono, 2021; Torun, 2020; Yeh et al., 2021), there remain significant challenges in effectively utilizing AI-powered tools within educational settings. Despite efforts to design educational programs that incorporate these tools within the TPACK framework, a gap persists in understanding how to optimize them to enhance teaching expertise among novice English teachers fully. In particular, current research has not sufficiently addressed the practical challenges educators encounter when adapting AI-powered tools—originally intended for professional or commercial use—into the English language learning curriculum. This gap underscores the need for further exploration into the development and implementation of educational programs that not only integrate AI-powered tools within the TPACK framework but also thoroughly evaluate their impact on teaching practices and learning outcomes in dynamic classroom environments. To address

this gap, this study designed a TPACK-based professional development program and subsequently evaluated its impact. The research questions to be examined in this study are as follows:

1. Does participation in the TPACK-based professional development program affect knowledge of AI-powered tools among novice English teachers?
2. Does participation in the TPACK-based professional development program improve novice English teachers' skills in using AI-powered tools for teaching?
3. Does participation in the TPACK-based professional development program affect self-efficacy in teaching with AI-powered tools among novice English teachers?

2. Literature Review

2.1 EFL Teacher Professional Development

The concept of professional development (PD) has been extensively explored, revealing its multifaceted nature across various contexts. Zeng (2023) describes PD as an ongoing journey of self-enhancement and behavioral improvement, while Bhatt (2021) emphasizes it as a continuous learning process aimed at refining teaching methods based on student needs. Thao et al. (2023) and Gudeta (2022) agree that PD involves enhancing teachers' knowledge, skills, and perspectives to improve student achievement. In essence, PD is not a one-time event but a continuous process that increases educators' knowledge, refines their skills, and enhances student outcomes.

PD programs are essential for teachers to remain current with evolving educational standards, instructional methods, and technologies. They also enable teachers to adapt to changing school environments and diverse student populations (Fairman et al., 2023). However, challenges such as limited time and resources can hinder participation. Online resources offer a solution, providing opportunities for both formal and informal learning that can improve teaching practices and classroom experiences (Nazari et al., 2020)

Several studies have investigated the impact of PD on teaching practices. Wulandari et al. (2021) found that collaborative and independent learning activities significantly enhance teaching competencies, while Ha and Murray (2021) observed that PD workshops and reflective exercises can shift teachers' views on corrective feedback. Zhang and Fang (2022) demonstrated that PD programs help teachers acquire essential teaching techniques, leading to improved student achievement.

Educational technologies have become integral to PD, particularly in fostering communities of practice. Cheng (2017) and Turgut (2017) explored the integration of technology into teacher education through the TPACK framework, highlighting the importance of combining technological, pedagogical, and content knowledge in enhancing teaching practices. Studies by Bostancıoğlu and Handley (2018), Drajati et al. (2018), and Budianto et al. (2023) further underscore the significance of TPACK in teacher PD, particularly in English Language Teaching (ELT).

Despite the advancements in PD practices, a gap remains in enhancing EFL teachers' TPACK through the integration of AI-powered tools. Existing studies have focused on general aspects of TPACK and technology integration in language education (Bostancıoğlu & Handley, 2018; Budianto et al., 2023; Cheng, 2017; Drajati et al., 2018; Ha & Murray, 2021; Turgut, 2017; Wulandari et al., 2021; Zhang & Fang, 2022), but there is a need for research that specifically addresses the incorporation of AI-powered tools into PD programs. Addressing this gap could lead to innovative strategies that empower EFL teachers to effectively utilize these tools for improved language teaching and learning outcomes.

2.2 Integrating AI-powered Tools in ELT

The continuous advancement of technology has prompted language educators to integrate it into their instructional methods, emphasizing the development of digital competencies essential for today's environment (Lai et al., 2022). New AI-powered tools in language teaching, such as Duolingo, Grammarly, and Quillbot, are transforming traditional educational models, offering personalized language lessons, and marking a significant shift in educational paradigms (Alshumaimeri & Alshememry, 2024).

AI-powered tools are revolutionizing education by offering scalable and innovative solutions to meet diverse educational needs (Lin et al., 2023; Narayan, 2024). These tools, including platforms like Coursera, Udacity, and Khan Academy, and technologies like Google AI and ChatGPT, have been widely adopted, although their impact has received mixed reactions among educators (Rasul et al., 2023). The rapid expansion of AI-powered tools in education continues to transform practices and stimulate discussions about their effectiveness.

In ELT context, AI-powered tools play a crucial role in enhancing language learning outcomes. Studies have explored various applications, including machine translation (Alharbi, 2023), automated writing evaluation (Fu et al., 2022), and speech training systems (Kang et al., 2024), demonstrating the potential of AI-powered tools to improve EFL education. However, concerns persist about the potential replacement of human teachers and the ethical implications of biases in AI systems (Toar et al., 2022).

Research across different regions highlights the growing adoption of AI-powered tools in ELT. In Saudi Arabia, China, South Korea, and Thailand, these tools are seen as advantageous for meeting instructional needs and engaging students (Abdalgane & Othman, 2023; An et al., 2023; Choi et al., 2023; Ulla et al., 2023). In Indonesia, AI-powered tools have significantly improved student writing quality and English proficiency, indicating the importance of continued support for these tools integration in education (Arini et al., 2022; Marzuki et al., 2023; Oktarin et al., 2024; Rusmiyanto et al., 2023; Waziana et al., 2024).

Despite the benefits of AI-powered tools, EFL teachers often lack the necessary training and proficiency to use these technologies in the

classroom effectively (Ng et al., 2023). There is a need for more empirical research and professional development programs to enhance TPACK, enabling them to utilize AI-powered tools effectively. Addressing this gap could lead to improved language teaching and learning outcomes, making it a critical area for future research.

3. Method

3.1 Participants

Forty novice English teachers from the province of Lampung, Indonesia, voluntarily participated in this study, with demographic information provided in Table 1. While the sample size was limited to 40 participants from a single region, the study offers valuable insights into the experiences of novice teachers in a specific context. Those participants were classified as novice teachers based on the criteria of having less than two years of teaching experience, recently completing a training program, or just beginning their teaching career (Gatbonton, 2008). This study employed purposive sampling to select research respondents, where the researchers applied inclusion criteria in recruiting participants. The criteria included (1) being an English teacher in Lampung, (2) having worked at a school for less than two years, (3) having experience in integrating AI-powered tools into teaching, and (4) being willing to participate in the study. Although the findings of this study may not apply to larger populations due to the regional focus and limited sample size, they offer valuable insights that can guide future research and practices in similar contexts.

Table 1. Participants' demographic information

Category	Count	Percentage (%)
Total Participants	40	100%
Male	5	12.5%
Female	35	87.5%
Teaching in Urban Schools	25	62.5%
Teaching in Rural Schools	15	37.5%

Among these participants, 5 (12.5%) were male, and 35 (87.5%) were female. The gender imbalance in the sample reflects the current demographic distribution of novice English teachers in the region, where female teachers are more prevalent in the teaching profession, particularly in the area of English language teaching. This is consistent with trends observed in other studies within similar contexts. While this imbalance may limit the generalizability of the findings to a more gender-diverse population, the study still provides valuable insights into the experiences of novice female teachers, who represent the majority of teachers in this region. Additionally, 25 (62.5%) were teaching in urban schools, while 15 (37.5%) were teaching in rural schools..

3.2 Research design

This study employed a quasi-experimental research design, utilizing a post-test-only control group format. The research involved two groups: an experimental group and a control group, each comprising 20 novice English teachers. The experimental group engaged in a PD program for English teachers, whereas the control group did not participate. Upon completion of the program, the researchers evaluated the teachers' post-test scores to collect data on their AI-powered tools self-efficacy scale, a rubric for evaluating AI-powered tools lesson plans, an AI-powered tools knowledge test.

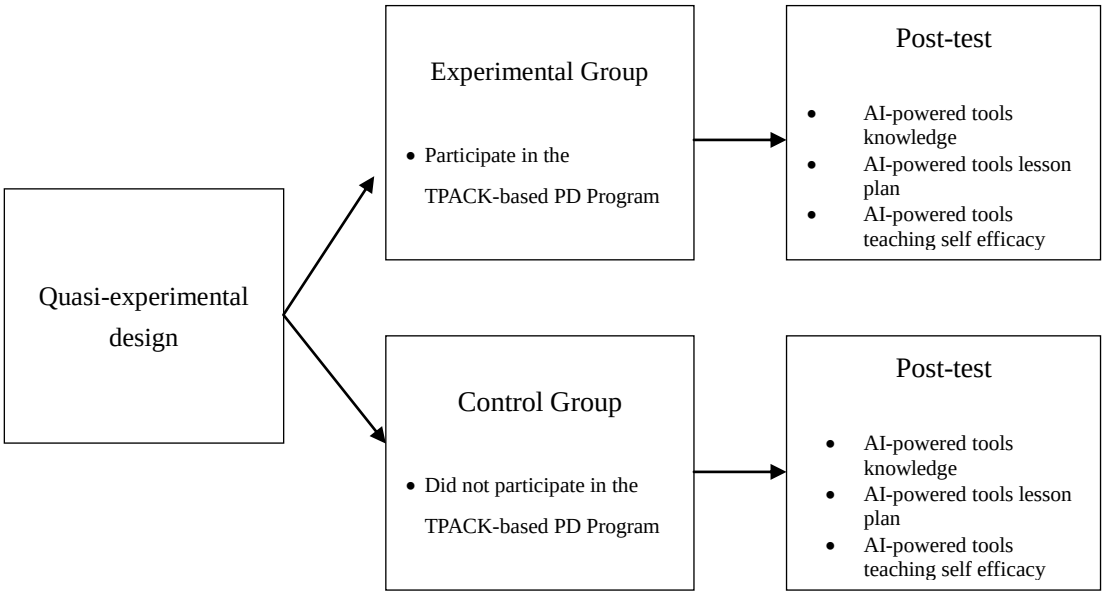

Figure 1. Research design

3.3 TPACK-based PD Program

This program focused on improving the instructional abilities of novice English teachers in the experimental group by integrating AI-powered tools. The program concentrated on five essential components: Content Knowledge with AI-powered tools (CK_{AI}), Technological Content Knowledge with AI-powered tools (TCK_{AI}), Pedagogical Content Knowledge with AI-powered tools (PCK_{AI}), Technological Pedagogical Knowledge with AI-powered tools (TPK_{AI}), and Technological Pedagogical Content Knowledge with AI-powered tools ($TPACK_{AI}$). CK_{AI} introduced the basic concepts of AI-powered tools, including the "five big ideas about AI-powered tools" (Celik, 2023) and their application in ELT, such as utilizing AI-powered tools to enhance vocabulary and grammar understanding. TCK_{AI} focused on the application of technology in English language education, such as using AI-powered tools to personalize lesson content. PCK_{AI} addressed effective teaching strategies and instructional design that leverage AI-powered tools to improve English language skills, such as simulating interactive dialogues using AI-powered tools. TPK_{AI} emphasized tools and technologies that support English language teaching with AI-powered tools, including Grammarly for automated grammar checks or ChatGPT for conversation practice and idea generation. $TPACK_{AI}$ highlighted the seamless integration of content, pedagogy, and technology, enabling teachers to craft lessons that combine AI-powered tools analysis with robust teaching methods. This PD program was crafted to equip novice English teachers with not only the knowledge of how to use AI-powered tools but also the ability to integrate them effectively into their teaching practices to enhance student learning outcomes.

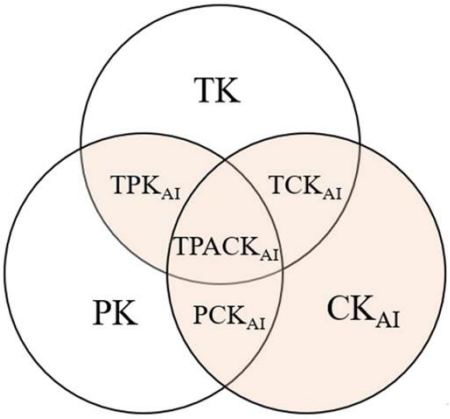

Figure 2. TPACK-based PD framework

According to the above figure, the PD program for English novice teachers, based on the TPACK framework, integrates AI-powered tools into teaching through five key modules. The first module introduces AI-powered tools concepts, focusing on their role in language learning and practical applications. The second module explores specific AI-powered tools for improving pronunciation, fluency, and personalized learning. The third module focuses on incorporating AI-powered tools into teaching strategies, with examples of successful integration. The fourth module helps teachers design lesson plans and assessments using AI-powered tools. The final module combines all previous knowledge, guiding teachers in creating effective AI-based projects and customizing tools for diverse learners. These modules equip English teachers to effectively use AI-powered tools in their teaching, enhancing both their methods and student outcomes.

Table 2. PD Activities Based on the TPACK Framework in the ELT Context

Module	Content	Hours
CKAI	**Understanding AI-powered tools Concepts for ELT (Online)**	16
	- Introduction to AI-powered tools in Language Learning - Key Concepts of AI-powered tools in ELT (e.g., Natural Language Processing, Machine Learning in language applications) - Ethical Considerations for AI-powered tools in Language Teaching - Role of AI-powered tools in Language Assessment and Feedback - Case Studies of AI-powered tools Applications in ELT - Hands-on Activities: Exploring AI-powered tools for English Language Learning	
TCKAI	**AI-powered tools and Technologies for ELT (Online)**	16
	- Exploration of AI-powered Language Learning Apps (e.g., Duolingo, Babbel) - Utilizing AI-powered tools for Pronunciation Improvement and Fluency Enhancement - Adaptive Learning with AI-powered tools for Personalized English Instruction - AI-powered tools Language Assessment Tools (e.g., automated grading systems, speech recognition) - Creating AI-powered tools-enhanced Resources for English Language Teaching	
PCKAI	**Pedagogical Strategies with AI-powered tools in ELT (Online)**	16

	- Integrating AI-powered tools into English Language Pedagogy - Designing AI-powered tools-enhanced Language Activities (e.g., collaborative projects, interactive exercises) - Effective Use of AI-powered tools in Teaching Vocabulary and Grammar - AI-powered tools in Language Skills Development (e.g., reading, writing, speaking, listening) - Case Studies: Successful AI-powered tools Integration in ELT	
TPKAI	**Instructional Design for AI-powered tools-enhanced ELT (Face-to-Face)**	16
	- Developing Lesson Plans with AI-powered tools (e.g., lesson planning software, content generation tools) - Using AI-powered tools to Enhance Classroom Interactions (e.g., real-time feedback, personalized learning paths) - Implementing AI-powered tools in Formative and Summative Assessments - Educational Apps and Platforms for AI-powered tools-driven Language Teaching	
TPACKAI	**Integrating AI-powered tools into ELT Practice (Face-to-Face)**	16
	- Combining AI-powered tools, Pedagogy, and Content Knowledge in ELT - Developing AI-powered tools-based Projects for Language Learning - Collaborative Learning with AI-powered tools - Reflection and Feedback: Analyzing the Impact of AI-powered tools on Language Learning Outcomes - Customizing AI-powered tools for Different Learner Needs	

3.4 Instrument

An AI-powered tools knowledge test was created to assess changes in teachers' understanding of AI-powered tools after the treatment. A set of lesson plan evaluation criteria was employed to evaluate teachers' skills in teaching with AI-powered tools. Additionally, an AI-powered tool teaching self-efficacy scale was utilized to measure improvements in teachers' confidence in using AI-powered tools for instruction, both prior to and following the intervention. Finally, semi-structured interviews were conducted to provide qualitative insights that complement the primary data.

3.4.1 AI-Powered Tools Knowledge Tests

The initiative to incorporate AI-powered tools into ELT was driven by the "5 Big Ideas" (Celik, 2023). To evaluate teachers' understanding following the PD sessions, an AI-powered tools knowledge test was developed. This test was created by a team consisting of two ELT researchers, with an educational technology expert reviewing it to ensure accuracy and relevance.

Table 3. AI-powered tools knowledge test

Test	Description
Post-test	1. There is a tool in AI-powered language learning that automatically corrects grammar and suggests improvements. This tool is called ( ). 2. Which of the following is not a feature of AI-powered language translation tools? ( ). 3. The development of AI-powered tools for language teaching has introduced new opportunities and challenges, including ( ). 4. The first step in developing a personalized learning path with AI-powered tools is ( ). 5. Natural language processing (NLP) is an essential application field for AI-powered tools in ELT. Which of the following is not a goal of NLP in language learning? ( ). 6. What safety and ethical considerations should be taken into account when using AI-powered tools in ELT? ( ).

The example items of the AI knowledge test can be seen in Table 3. The test comprised 15 multiple-choice questions aligned with the "5 Big Ideas." Ten of these questions had a single correct answer, while the remaining five allowed for multiple correct answers. Scoring was set at 1 point for correctly answered single-answer questions and 2 points for fully correct multiple-answer questions, with partial credit awarded for partially correct responses. To ensure content validity, the questions were developed in consultation with a panel of three experts in the field of AI and ELT, who reviewed the items to confirm their alignment with the "5 Big Ideas" framework. Construct validity was assessed through a pilot study involving 30 participants, where item analysis was conducted to examine the discrimination index and difficulty coefficient. The test achieved a Cronbach's alpha of 0.85, reflecting a high level of reliability. The discrimination index varied between 0.45 and 0.60, with the difficulty coefficient falling within a range of 0.50 to 0.70, indicating an appropriate level of item difficulty and discrimination, which supports both the reliability and validity of the instrument.

3.4.2 Assessment Criteria for Lesson Plans Utilizing AI-Powered Tools

To evaluate the ability of novice EFL teachers to create AI-powered lesson plans, the researchers developed a specialized rubric as assessment criteria for lesson plans (as detailed in Table 4). This rubric was adapted from a previous study (Kwangsawad, 2016; Muslim & Sumarni, 2023; Zein et al., 2020).To ensure content and structural validity, the researchers followed a multi-step process. First, a team of three subject matter experts in educational technology and EFL instruction reviewed the rubric to confirm its alignment with key learning objectives and its relevance to AI-powered lesson planning. The rubric was then piloted with a sample of 20 novice EFL teachers to evaluate its clarity and applicability in real-world settings. Based on feedback from the pilot study, revisions were made to improve the clarity of the rubric's items and ensure they accurately captured the intended constructs. The final version of the rubric was refined based on the expert feedback and pilot study results. To assess the reliability of the rubric, inter-rater reliability was tested by having two independent raters

score a subset of lesson plans using the rubric. A high level of agreement (Cohen's kappa = 0.87) was found between the raters, indicating strong reliability. The rubric consists of three sections, as seen in Table 4—learning objectives, content, and activities—each with nine items scored as 1 (met) or 0 (not met), for a total possible score of 9.

Table 4. Evaluation criteria for lesson plans incorporating AI-powered tools

Category	Criteria	Source
Learning objectives	Be precise and consistent with language learning objectives	Muslim and Sumarni (2023)
	Combine with students' language proficiency levels	Kwangsawad (2016)
	Reflect the core competencies of ELT (e.g., communication, comprehension)	Zein et al. (2020)
Learning content	Be accurately and specifically described in terms of language skills (e.g., reading, writing)	Muslim and Sumarni (2023)
	Integrate AI-powered tools effectively within language learning tasks	Zein et al. (2020)
	Relate to real-life language use scenarios	Kwangsawad (2016)
Learning activities	Be adaptable and responsive to various learning needs	Kwangsawad (2016)
	Ensure alignment with the learning objectives	Muslim and Sumarni (2023)
	Reflect project-based or task-based learning approaches	Zein et al. (2020)

3.4.3 AI-powered Tools Teaching Self-Efficacy Scale

Abedini et al. (2018) created a 5-point Likert scale designed to evaluate teachers' confidence in their instructional effectiveness, concentrating on two fundamental aspects. They are English teaching outcome expectancy and English teaching efficacy beliefs. The scale comprises 21 items, each rated on a scale from 1-5 (strongly disagree to agree strongly). This scale was adapted to assess the confidence of novice EFL teachers in using AI-powered tools of novice EFL teachers, with some items modified or removed, as detailed in Table 5. The adapted scale consists of 10 items that capture AI-powered tools teaching outcome expectancy and AI-powered tools teaching efficacy beliefs. To ensure the validity of the adapted scale, the researchers conducted a two-step validation process. First, a panel of three experts in the fields of EFL teaching and educational technology reviewed the revised scale for content and face validity. Based on their feedback, minor revisions were made to improve clarity and relevance. Second, construct validity was assessed using exploratory factor analysis (EFA) with a sample of 50 novice EFL teachers, which confirmed the scale's factor structure. The validity and reliability of the revised scale were tested with a sample of 50 novice EFL teachers. The KMO value was 0.811, which is greater than 0.7, indicating a significant correlation among the items. The factor loading values ranged from 0.54 to 0.78, exceeding the threshold of 0.45. The scale demonstrated satisfactory reliability and consistency, with an alpha coefficient of 0.818, which surpasses the acceptable threshold of 0.7.

Table 5. AI-powered tools teaching self-efficacy scale

Criteria	Number	Description	Component 1	Component 2
AI-powered tools teaching efficacy beliefs	1	I have a strong understanding of AI-powered tools that allow me to teach English language skills effectively.	0.884	
	2	I possess the skills required to effectively teach English language concepts using AI-powered tools.	0.876	
	3	I am capable of adapting AI-powered tools to meet the language learning needs of my students.	0.864	
	4	I struggle to explain to students how AI-powered tools can support their language learning.	0.753	
	5	I can usually handle students' inquiries about utilizing AI-powered tools in their language learning.	0.742	
AI-powered tools teaching outcome expectancy	6	The influence of AI-powered tools on students' improvement in English language skills is frequently overestimated.		0.732
	7	When students' English language skills improve, it is often attributed to the effectiveness of the AI-powered tools employed in teaching.		0.846
	8	The application of AI-powered tools in teaching has a notable effect on students' language learning outcomes.		0.834
	9	The impact of AI-powered tools in language teaching has little influence on the performance of low motivation students.		0.772
	10	AI-powered tools substantially boost students' motivation to learn English.		0.768

3.4.4 Semistructured Interview

To evaluate the competency of AI-powered tools teaching and the impact of the PD program in this study, a semi-structured interview was conducted centered on the following questions: What have you gained from PD activities, and what are your thoughts or emotions about your experience? Are you more confident about incorporating AI-powered tools into your English language teaching or guiding students in using these tools in the future? Why or why not? What challenges do you anticipate encountering when incorporating AI-powered tools

into your English language teaching after participating in this program?

3.5 Data Collection and Analysis

A single online questionnaire was developed, consisting an AI-powered tools knowledge test and of an AI-powered tools teaching self-efficacy scale, to gather quantitative data efficiently. Valid responses were filtered using the pairwise deletion method (Graham, 2009). Valid responses were assessed for normality using the Shapiro-Wilk test due to the sample size being fewer than 50 participants. The results showed that post-tests for AI-powered tools teaching efficacy and knowledge of AI-powered tools were normally distributed. Consequently, an independent sample t-test was conducted to analyze the data.

Works from four groups were collected for the AI-powered tools lesson plans. Two evaluators participated in a preliminary trial, where two lesson plans were randomly selected and assessed. The Cronbach's alpha for this trial was 0.824, exceeding the threshold of 0.8. Following the trial, the evaluators discussed their differences and arrived at a consensus. Subsequently, a Cronbach's alpha coefficient of 0.892 was achieved after the two evaluators independently scored all the lesson plans.

For the semi-structured interviews, the researchers purposefully selected five participants. A four-step thematic analysis process was employed to analyze the qualitative data (Braun et al., 2014)—pre-established coding nodes based on AI-powered tools self-efficacy, teaching skills, and knowledge. Initially, two researchers independently coded a sample of the interview data. They proceeded by discussing their findings and then independently re-coded all the interview data.

4. Results

4.1 Impact of TPACK-based Professional Development Program on AI-powered Tools Knowledge among Novice English Teachers

Table 6. Result of AI-powered tools knowledge test

Group	N	Mean	Std. Deviation	Std. Error Mean
Experimental Group	20	85.25	3.65	.81
Control Group	20	68.15	5.86	1.31

Table 6 shows the results of the AI-powered tools knowledge test for the two groups. The experimental group, made up of 20 students, scored an average of 85.25. Their performance was fairly consistent, with a standard deviation of 3.65 and a standard error of 0.81. In comparison, the control group, also comprising 20 students, had a lower average score of 68.15. Their scores displayed greater variability, with a standard deviation of 5.86 and a standard error of 1.31. These findings suggest that the experimental group outperformed the control group in this area. Therefore, this indicates that the TPACK-based professional development program has a positive impact on knowledge of AI-powered tools among novice English teachers in the experimental group.

Table 7. Independent Samples Test for AI-powered tools knowledge test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Post-test	Equal variances assumed	2.23	.144	11.07	38	.000	17.10	1.54	13.97	20.22
	Equal variances not assumed			11.07	31.836	.000	17.10	1.54	13.95	20.24

Before conducting the independent samples t-test, the researchers first performed normality and homogeneity tests. As presented in Table 7, the results show a Sig. (2-tailed) value of less than 0.05, indicating a significant difference in the AI-powered tools knowledge test results between the experimental and control groups. Thus, the TPACK-based professional development program significantly impacts knowledge of AI-powered tools among novice English teachers in the experimental group.

4.2 Impact of a TPACK-Based Professional Development Program on Novice English Teachers' Skills in Using AI-Powered Tools for Teaching

Table 8. Result of Novice English Teachers' Skills in Using AI-Powered Tools for Teaching

Group	N	Mean	Std. Deviation	Std. Error Mean
Experimental Group	20	87.25	3.65	.821
Control Group	20	64.40	5.97	1.33

Table 8 presents the test results of novice English teachers' proficiency in using AI-powered tools for teaching across the two groups. The experimental group, consisting of 20 participants, achieved an average score of 87.25, with consistent performance reflected by a standard deviation of 3.65 and a standard error of 0.82. In contrast, the control group, also composed of 20 participants, recorded a lower average score of 64.40, with greater variability, as indicated by a standard deviation of 5.97 and a standard error of 1.33. These results suggest that

the experimental group outperformed the control group in this domain. Consequently, this indicates that the TPACK-based professional development program positively influences novice English teachers' skills in using AI-powered tools for teaching in the experimental group.

Table 9. Independent Samples Test for Novice English Teachers' Skills in Using AI-Powered Tools for Teaching

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Post-test	Equal variances assumed	2.931	.095	14.58	38	.000	22.85	1.566	19.67	26.02
	Equal variances not assumed			14.58	31.46	.000	22.85	1.566	19.65	26.04

Before conducting the independent samples t-test, the researchers first performed normality and homogeneity tests. As presented in Table 9, the results show a Sig. (2-tailed) value of less than 0.05, indicating a significant difference in novice English teachers' skills in using AI-powered tools for teaching results between the experimental and control groups. Thus, the TPACK-based professional development program significantly influences novice English teachers' skills in using AI-powered tools for teaching in the experimental group.

4.3 Impact of TPACK-based Professional Development Program on Self-efficacy In Teaching with AI-powered Tools Among Novice English Teachers

Table 10. Result of self-efficacy test in teaching with AI-powered tools among novice English teachers

Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Experimental Group	20	81.05	3.67	.82
Control Group	20	70.95	5.78	1.29

Table 10 shows the results of a self-efficacy test in teaching with AI-powered tools for the two groups. The experimental group, made up of 20 students, scored an average of 81.05. Their performance was fairly consistent, with a standard deviation of 3.67 and a standard error of 0.82. In comparison, the control group, also comprising 20 students, had a lower average score of 70.95. Their scores displayed greater variability, with a standard deviation of 5.78 and a standard error of 1.29. These findings suggest that the experimental group outperformed the control group in this area. Therefore, this indicates that the TPACK-based professional development program has a positive impact on self-efficacy in teaching with AI-powered tools among novice English teachers in the experimental group.

Table 11. Independent Samples Test of self-efficacy test in teaching with AI-powered tools among novice English teachers

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Post-test	Equal variances assumed	3.59	.066	6.59	38	.000	10.10	1.53	6.99	13.20
	Equal variances not assumed			6.59	32.21	.000	10.10	1.53	6.98	13.21

Prior to conducting the independent samples t-test, the researchers carried out normality and homogeneity tests. As shown in Table 11, the results revealed a Sig. (2-tailed) value of less than 0.05, indicating a significant difference in self-efficacy test results for teaching with AI-powered tools between the experimental and control groups. Therefore, the TPACK-based professional development program has a significant impact on enhancing self-efficacy in teaching with AI-powered tools among novice English teachers in the experimental group.

4.4 Interview Data Analysis Results

The interview data were organized into three themes that aligned with the three research questions. The frequency of mentions related to AI-powered tools and teaching abilities is summarized in Table 12. All five interviewees shared positive perspectives on "AI-powered tools knowledge," with this theme mentioned 14 times. "AI-powered tools teaching efficacy skills" were referenced 12 times, while "AI-powered tools teaching self-efficacy" was mentioned eight times.

Table 12. Frequency counts of AI-powered tools teaching ability

Theme	Codes frequency	Frequency of participants among 5
AI-powered tools knowledge	14	5
AI-powered tools teaching efficacy skills	12	4
AI-powered tools teaching self-efficacy	8	4

Regarding AI-powered tools knowledge, teacher T3 shared, "*I've gained much knowledge about AI-powered tools this time. For instance, I've explored various language learning apps and learned how to integrate them into my teaching*." Teacher T1 remarked, "*Before this training program, I didn't know much about AI-powered tools. I have gained a basic understanding of these tools and am more assured in utilizing them to improve my English lessons*."

Regarding teaching skills with AI-powered tools, teacher T4 observed, "*Our school has been using language learning software like Duolingo, but I mainly relied on traditional teaching methods due to a lack of proper technology integration and hands-on practice. I'm particularly interested in incorporating AI-powered tools into my English teaching after this training.*" Teacher T5 commented, "*I now know how to use AI-powered tools, like language translation apps, in my classes after the training, and I can adapt the lesson plans provided by experts for my students. Additionally, I've learned how to design English lessons that integrate AI-powered tools, and I believe I've made considerable progress."*

Concerning self-efficacy in teaching with AI-powered tools, teacher T2 remarked, "*I plan to modify my English curriculum to incorporate some AI-powered tools when I return to school and I incorporate activities designed to increase students' familiarity with these tools*." Teacher T4 added, "*I will request that our school purchase more AI-powered language learning tools, and I plan to learn how to use them creatively myself. I am enthusiastic about continuing my studies and helping my students integrate their ideas with these new technologies*."

5. Discussion

Earlier studies have demonstrated that TPACK serves as a successful model PD progras aimed at EFL teachers (Kusuma, 2021, 2022; Nazari et al., 2020; Tømte et al., 2015); however, only a limited number of studies have utilized the TPACK model to improve the AI-powered teaching skills of novice EFL teachers. As far as we know, this study might be the first empirical investigation to employ a TPACK-based professional development approach to cultivate AI-powered teaching skills in novice EFL teachers. Our current results indicate that this program substantially enhanced their proficiency in teaching with AI-powered tools, including improvements in self-efficacy, teaching skills, and knowledge of AI-powered tools. The implications of these findings, along with practical applications, are discussed in the following paragraphs.

To improve the competency of novice EFL teachers in using AI-powered tools for instruction, we implemented this TPACK-based professional development program, incorporating a comprehensive content structure within a series of blended learning activities. The program specifically focused on developing CK_{AI}, PCK_{AI}, TCK_{AI}, TPK_{AI}, and $TPACK_{AI}$ among novice EFL teachers. This innovative content design builds on and expands the findings of previous studies on PD for novice EFL teachers, which have typically concentrated on fundamental EFL areas such as grammar instruction, vocabulary building, reading comprehension, speaking and listening skills, and writing (Aniq & Drajati, 2019; Kusuma, 2022; Lai et al., 2022; Muslimin et al., 2023; Nazari et al., 2019, 2020). This TPACK-based program was conducted in blended format, focusing on key aspects of effective professional development, like the use of models, collaboration, and active learning, as emphasized by Abubakir and Alshaboul (2023), Lai et al. (2022) and Lisa et al. (2021). The PD program activities were centered on practical, hands-on experiences, including the use of AI-powered tools to create interactive language exercises and collaborative lesson planning with peers to integrate these tools into the ELT context effectively.

In terms of the effectiveness of this PD program, the statistical analysis comparing the experimental group with the control group revealed a significant increase in novice EFL teachers' knowledge of AI-powered tools after participating in the program. This outcome is consistent with previous research that has shown how technology integration in PD programs can enhance teachers' understanding of tools and technologies for language teaching (Hastomo et al., 2024). While the TPACK-based PD program was generally successful, there is still room for improvement. For instance, greater emphasis could be placed on providing practical classroom applications of AI-powered tools, offering ongoing support as teachers integrate these tools into their teaching, and incorporating more collaborative activities that allow teachers to share best practices and learn from each other's experiences.

Secondly, most novice EFL teachers' lesson plans incorporating AI-powered tools successfully adhered to the required standards, particularly in the designated areas of "being precise and consistent with language learning objectives," "reflecting the core competencies of ELT," "effectively integrating AI-powered tools within language learning tasks," and "relating to real-life language use scenarios." This result indicates that teachers' PCK regarding AI-powered tools was enhanced through this TPACK-based professional development program. Nevertheless, a limitation of this PD program is that project-based learning was insufficiently represented in the lesson plans of most groups. Project-based learning has been widely used in language education with positive results as a learner-focused constructivist. Celik (2023) also emphasized the need to carefully blend teaching methodologies with information technology to foster students' information literacy and creative thinking in their courses using AI-powered tools. As a result, this gap in the PD program should be revised in future iterations.

Finally, PD in this study led to a significant improvement in novice EFL teachers' self-efficacy in using AI-powered tools for teaching. This result is consistent with the findings of Kapici and Akcay (2023), who demonstrated that lesson planning in a supportive environment

with appropriate technological tools can greatly enhance teachers' self-efficacy. The TPACK-based program, which featured various professional learning activities combined with practical experience in using AI-powered tools for language teaching—likely played a key role in increasing novice EFL teachers' teaching confidence. Consequently, high self-efficacy in using AI-powered tools may positively impact their teaching practices and lead to better language learning outcomes for students, as suggested by previous research on teaching self-efficacy (Yilmaz & Yilmaz, 2023).

In summary, this research represents one of the earliest empirical, evidence-based efforts to improve the ability of novice EFL teachers in utilizing AI-powered tools. The program in this study was uniquely crafted using the TPACK-AI framework (Celik, 2023) and also integrated essential components of effective TPD as outlined by Abubakir and Alshaboul (2023), Lai et al. (2022) and Lisa et al. (2021). Another significant contribution of this study is the use of multiple assessment instruments to evaluate EFL teachers' competency in using AI-powered tools. In contrast to earlier studies that investigated the impact of TPACK-based professional development programs on EFL teachers (Kusuma, 2021, 2022; Nazari et al., 2020; Tømte et al., 2015), the evaluation method employed in this current study was more comprehensive and could enhance the validity and reliability of the results.

The main implication of this study is the successful design of PD programs for novice EFL teachers, specifically in the integration of AI-powered tools into their teaching practices. Given the shortage of novice EFL teachers who are adequately prepared to use AI-powered tools effectively in language instruction (Hastomo et al., 2024), it is essential to create top-tier PD programs that enhance novice EFL teachers' competencies, addressing both cognitive and non-cognitive aspects. PD content should highlight teaching methods connected to specific curriculum content that support educators' understanding of classroom contexts in line with the principles of effective TPD (Cahyono et al., 2016). This study embodied this principle by focusing intentionally on AI-powered tools in language teaching and constructivist pedagogies, categorized into CK_{AI}, TCK_{AI}, PCK_{AI}, TPK_{AI}, and $TPACK_{AI}$. The findings demonstrated that this TPACK-based content design positively influenced novice EFL teachers' self-efficacy, teaching skills, and knowledge in using AI-powered tools for language instruction. Moreover, the PD program incorporated active teacher learning by directly involving novice EFL teachers in the creation of AI-related teaching materials and the design of lesson plans. Additionally, the program facilitated opportunities for them to exchange ideas and work together in their professional development, highlighting the "collaboration" aspect of successful PD. This program may have significant practical implications for many PD initiatives aimed at improving the use of AI-powered tools among EFL teachers in the Indonesian context.

6. Conclusion

To enhance EFL teachers' proficiency in using AI-powered tools, this study developed and applied a TPACK-based PD program. Following the intervention, the program a) positively impacted novice EFL teachers' knowledge of AI-powered tools, b) advanced their teaching skills with AI tools, including the ability to create effective lesson plans and integrate these tools into language instruction, and c) significantly boosted their self-efficacy in using AI-powered tools. These outcomes highlight the influence of a TPACK-based PD program in enhancing EFL teachers' competency in utilizing AI-powered tools for language teaching. The findings also contribute to and enhance current research and practices in creating effective professional development programs for EFL teachers, with a focus on incorporating AI technology into education.

This study offered valuable insights into the integration of AI-powered tools within the TPACK framework to enhance the teaching competencies of novice EFL teachers. However, several limitations must be acknowledged. First, the sample size was relatively small and confined to a specific region, which may limit the generalizability of the findings. Additionally, although the study's quasi-experimental design was robust, it may still be subject to biases that could influence the results. Future research should consider expanding the sample size and including participants from diverse geographic and educational backgrounds to improve the generalizability of the findings. Moreover, conducting longitudinal studies could provide a deeper understanding of the long-term effects of TPACK-based professional development programs on teaching efficacy and student outcomes. Further research is also recommended to explore the integration of AI-powered tools within other teaching frameworks and disciplines, as well as to investigate the specific challenges and best practices for adapting these tools in diverse educational settings.

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Authors' contributions

Hajjah Zulianti led the design of the study and made significant revisions to the content. Eva Nurchurifiani and Hastuti contributed to the manuscript's improvement and development. Tommy Hastomo and Aksendro Maximilian handled proofreading and made revisions to the writing mechanics. Galuh Dwi Ajeng was in charge of reviewing and organizing the final manuscript. All authors approved the final version of the manuscript at both the submission and revision stages during the peer review process.

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The authors declare that they have no conflicting financial interests or personal relationships that could have influenced the work presented in this paper.

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