Scrutinizing Indonesian pre-service teachers' technological knowledge in utilizing AI-powered tools

Tommy Hastomo[1,3], Berlinda Mandasari[2,3], Utami Widiati[3]
[1]Department of English Education, STKIP PGRI Bandar Lampung, Lampung, Indonesia
[2]Department of English Education, Faculty of Arts and Education, Universitas Teknokrat Indonesia, Lampung, Indonesia
[3]Department of English, Faculty of Letters, Universitas Negeri Malang, Malang, Indonesia

Article Info	ABSTRACT
	Educators have widely adopted artificial intelligence (AI) as a product of technology to prepare teaching materials and enhance their understanding of technology integration in language teaching. As prospective teachers who may teach digital native students later, pre-service teachers must be more capable and knowledgeable in technologically-based pedagogy, materials, and assessment. This study aimed to explore English as a foreign language (EFL) pre-service teachers' technological knowledge of utilizing AI-powered tools using the technological pedagogical content knowledge (TPACK) framework and investigate their strategies in the advanced of their technological knowledge. This mixed-method research design employed a five-point Likert scale questionnaire and a semi-structured interview as instruments to collect data. Fifty-five EFL pre-service teachers were purposively selected. Data from the questionnaire were analyzed statistically and descriptively, and data from interviews were analyzed thematically. The first findings of this study comprehensively revealed that EFL pre-service teachers exhibit a moderate level of proficiency in addressing technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and TPACK in utilizing AI-powered tools. Meanwhile, the second finding revealed that the participants employed four key strategies to advance their technological knowledge using AI-powered tools: engaging in TPD programs, collaborating with tech-savvy colleagues, staying informed about AI trends, and experimenting with AI-powered tools. *This is an open access article under the <u>CC BY-SA</u> license.*

Corresponding Author:

Tommy Hastomo
Department of English Education, STKIP PGRI Bandar Lampung
St. Chairil Anwar, No.79, Kota Bandar Lampung, Lampung, Indonesia
Email: tomhas182@gmail.com

1. INTRODUCTION

In this modern era, teachers should employ technology to enrich their teaching practices, as their expertise has extended beyond the specific content, they have to convey to encompass pedagogical principles and strategies. Some teachers believed technology courses in their education programs were valuable, as not all teachers effectively incorporated technology into teaching and learning [1]. Several higher education institutions consider it crucial for future English teachers to gain cutting-edge lesson plans and stay updated on technological proficiency [2]. Such preparation may help these future English teachers adopt and adapt educational technology in their teaching programs. Faculty members have used technological pedagogical content knowledge (TPACK) to integrate technology into teaching.

The TPACK framework was employed in this current research to assess the technological knowledge of English as a foreign language (EFL) pre-service teacher. This framework may help them understand how to integrate technology into a curriculum most efficiently [3]–[5]. In the EFL context, using this framework is crucial because there may be little opportunity for exposure to the target language outside of the classroom [5]. Technology integration is one way to include English beyond the classroom [6]. Using TPACK, the teachers can comprehend the possible advantages of introducing new technology into the classroom.

Multiple scholars have employed the TPACK framework to examine the incorporation of technology in teaching and learning activities. A previous study discovered that EFL pre-service teachers employed TPACK to develop their ability to design and implement technology-integrated lessons in real classroom environments [7]. The engagement of pre-service teachers within the higher education setting facilitated the development of their TPACK and the subsequent incorporation of TPACK principles into their instructional approaches [8]. In the context of undergraduate programs, it has been observed that inadequate preparation leads to a deficiency in technology integration and information and communication technology (ICT) competencies among EFL pre-service instructors [9]. Guided by the TPACK framework, another piece of research examined the perceived self-efficacy beliefs and attitudes toward mobile technology-enhanced instruction (specifically, iPad usage) among three elementary teachers. This past research has utilized the TPACK framework to evaluate teaching and technology integration [10]. However, none seems to have specifically explored the incorporation of artificial intelligence (AI) in education within the Indonesian context. This highlights a research gap in applying TPACK to assess the assimilation of AI technologies, especially AI-powered tools, in teaching and learning English in Indonesia.

AI technology integration is particularly significant in EFL instruction in educational settings. As English is crucial in international communication, proficiency in English is a valuable skill and often a prerequisite for success in an increasingly interconnected world [1], [11]. EFL instruction has become a cornerstone of educational curricula in many non-English-speaking countries, aimed at equipping students with the linguistic skills required for global communication [12]. Some research studies of AI-powered tools can be categorized into some research topics, such as machine translation [13], automated writing evaluation [14], automated writing scoring [15], intelligent tutoring systems for speech training [16], and natural language and vocabulary learning [17]. Therefore, the intersection of technology and instruction has held insightful implications for enhancing language learning outcomes for EFL students.

As they have been massively adopted in EFL teaching, AI-powered tools provide some critical concerns. There are concerns about the potential for AI to replace human teachers and ethical concerns related to bias in AI algorithms [18]. There were uncertainties about the precision of AI, specifically AWE, as it could not assess the subjective characteristics of natural languages [19]. Meanwhile, another study stated that students voiced their discontent regarding specific feedback given by the writing system, perceiving it as perplexing [20]. Social issues in AI language education included biased discourse analysis when AI was trained on data and algorithms with societal biases, potentially resulting in social inequalities or lack of cohesion [21]. EFL pre-service teachers must navigate and address the above concerns while integrating AI-powered tools into their teaching practices.

Research has extensively investigated the global usage of AI-powered technologies among EFL teachers, showing a significant increase. Previous research claimed that digital and AI-powered tools can aid the educational aspect of future schooling in Saudi Arabia [22]. EFL teachers in China believed that AI technology was highly beneficial for their teaching and considered it user-friendly [23]. In South Korea, integrating AI can help educators keep students engaged and motivated, improving academic performance [24]. A study in China highlighted the numerous opportunities AI introduced to EFL education, such as developing AI-driven teaching tools, enhancing teachers' technological skills, and addressing the equilibrium between teacher, machine, and student [25]. Moreover, EFL teachers at a Thai university expressed favorable attitudes toward AI tools and recognized their versatile functions. These functions encompass lesson planning and crafting language activities [26]. Previous studies indicate that future teachers need the potential to instruct digital-native students, inseparable from technology, showcasing diverse insights and underscoring the universal benefits of technology through positive perspectives and practical applications across varied cultural and educational settings.

In Indonesia, numerous studies have examined the adoption of AI-powered tools among EFL teachers. AI writing tools enhanced the quality of EFL student writing [27]. Similarly, mobile AI-based learning has greatly improved students' English proficiency because it provides more learning opportunities [28]. Meanwhile, AI holds the potential to significantly improve the communication skills of English language learners through the provision of personalized and interactive learning experiences [29]. Moreover, AI tools could undeniably benefit from in-service English retraining, focusing on enhancing their language proficiency [30]. The previous research confirmed that the integration of AI has the potential to benefit students in expanding their English language skills.

EFL pre-service teachers may have varying degrees of expertise in integrating AI-powered tools in an educational setting. They may not have enough knowledge and skills related to AI, which would hinder their capacity to implement AI-powered tools effectively in the classroom. Similarly, they may not have enough opportunities in teacher preparation programs to learn about AI and its uses in the classroom [31]. Experience, teaching quality, and feature set are three factors that might impact a user's degree of proficiency using AI-powered tools [32]. Teachers may educate their students more successfully and economically when given the tools to improve their AI integration abilities. Additional empirical studies on pre-service teachers' use of AI are needed to improve their awareness and skills, ultimately fostering a more effective adoption of AI-powered tools in future classrooms.

Despite the increasing interest in using AI-powered tools among EFL teachers [22]–[30], little was known about exploring the adoption of AI-powered tools among pre-service teachers using the TPACK framework. There is a need for more exploration of pre-service teachers' technological level of knowledge on integrating AI-powered tools in EFL classrooms, particularly in the Indonesian context. This notion seemed logical while thinking that in the future, pre-service teachers may be expected to teach digital native students who will have side by side with technological devices by then. Thus, their readiness to embrace technology and technological knowledge should be better prepared a long way before they graduate with their bachelor's degree. Through their teacher education programs, pre-service teachers need to be equipped with knowledge about current AI tools with which digital native students are generally familiar and skills in employing the strategies of using the tools for instructional. In short, endowing pre-service teachers with technological knowledge is urgent.

Referring to the identified concerns, this study attempts to address these research questions: i) what are EFL pre-service teachers' levels of technological knowledge in the respective domains of TPACK toward integrating AI-powered tools?; and ii) how do EFL pre-service teachers advance their technological knowledge in the respective domains of TPACK?

2.   METHOD

2.1. Design

This study employed a mixed method research. To better understand a research issue, a mixed methods research approach entails collecting, assessing, and combining quantitative and qualitative research techniques within a unified study [33]. A mixed method may yield stronger results than using either method alone. Concerning the current study, mixing the method is expected to quantitatively investigate the level of technological knowledge in their respective domains and qualitatively capture how pre-service teachers enhance their technological proficiency.

2.2. Participant

This study included 55 out of 120 EFL pre-service teachers from three reputable universities in Bandar Lampung. Ten male and forty-five female participants were included in this study. In particular, the participants' demographic information was presented in Table 1.

Table 1. Participants demographic information

Number	Gender	Range of age
45	Female	19-21
10	Male	19-21

A purposive sampling method was chosen as the sampling technique in this study based on specific criteria: i) the participants were third-year students majoring in English education and had completed all the ELT methodology, English instructional technology, lesson plans, and microteaching courses available during their undergraduate studies and a foundational course in digital literacy; and ii) the participants were about to conduct a teaching practicum. Even though they had not had practical experience teaching in the classroom, they had been taught how to create a lesson plan that compulsorily employs AI-powered tools as teaching media. Then, they also had teaching simulations based on the lesson plan they made. Teachers gave feedback during simulations. Thus, this activity made them more well-prepared to conduct teaching practicum at some schools. Additionally, they were ambitious students with a strong drive for continuous professional growth and were deemed to acquire high English language competence. Ensuring ethical standards was essential when undertaking research with human participants. Consequently, in this study, the decision was made to secure informed consent to safeguard the confidentiality and privacy of the participants.

2.3. Instruments

The research instrument used in the study employed multiple data collection methods to gather data comprehensively. This study used a questionnaire and a semi-structured interview as research instruments. The questionnaire was adapted from Celik [34] because it is the latest instrument developed with established TPACK scales and various data collection instruments related to teachers' utilization of AI-based. Exploratory factor analysis (EFA) was employed using SPSS 24 to assess construct validity and set a factor loading cutoff at 0.40 [35]. After conducting EFA, confirmatory factor analysis (CFA) was utilized to examine TPACK factors with the theoretical framework [36]. IBM Amos 22.0 was utilized to examine skewness and kurtosis coefficients, ensuring the normality assumptions of CFA were met. Item-total correlation and internal consistency were computed to assess the scale's reliability, with Cronbach's alpha consistency coefficient indicating satisfactory internal consistency at 0.70 or higher. In this current study, this instrument was employed to investigate the technological knowledge in related domains of EFL pre-service teachers in utilizing AI-powered tools, as outlined in the first research question, using the TPACK framework. This questionnaire consisted of 23 statements, which employed a five-point Likert scale ranging from strongly disagree (1) to agree strongly (5). The detailed distributions were presented Table 2.

Additionally, this study employed a semi-structured interview to evaluate the technological knowledge advancement of EFL pre-service teachers, as outlined in the second research question. The interview questions, derived from the questionnaires, focused on strategies for enhancing technological knowledge in related domains. Eight guided questions were initially used, with some modifications for relevance.

Table 2. Questionnaire map on TPACK components

Questionnaire	Number of items	Component	Number of component items
EFL pre-service teachers' levels of technological knowledge toward integrating AI-powered tools	23	TK	5
		TCK	7
		TPK	4
		TPACK	7

2.4. Data collection

Various data collection methods were employed in the research. The first method was a survey via Google Forms, which captures quantitative data on pre-service teachers' technological knowledge in related domains utilizing AI-powered tools in EFL classrooms. These Google Forms were distributed to the EFL pre-service teachers via WhatsApp, assisted by the head of a study program and faculty members. The second method was an interview. The researchers left a question asking whether they were willing to participate in an interview session by providing their WhatsApp number on the questionnaire. The interviews were conducted via Zoom Meetings, lasting 20 minutes each. Among 55 participants, there were 10 participants confirmed to participate in the interview sessions. The sessions were recorded with the participant's consent to guarantee the validity and accuracy of the data.

2.5. Data analysis

Data gathered via the Google Forms survey were analyzed using IBM SPSS statistics 26 to obtain the mean and standard deviation scores. Meanwhile, data gathered from semi-structured interviews were analyzed thematically. To begin with, the researchers coded the interview recording. This process was repeated multiple times to ensure the information was accurate and comprehensive. Data coding required closely examining the data, identifying noteworthy trends, prioritizing recurring terms, and ultimately developing themes. Only the relevant findings were presented.

3.   RESULTS AND DISCUSSIONS

3.1. EFL pre-service teachers' levels of technological knowledge in the respective domains of TPACK toward integrating AI-powered tools

The initial goal of this research was to assess the extent of technological knowledge EFL pre-service teachers have regarding the integration of AI-powered tools measured through the TPACK framework. The researchers utilized quantitative tools like a five-point Likert scale questionnaire to achieve this goal. The researchers subsequently processed and analyzed the questionnaire data using SPSS version 26. In order to derive meaningful insights from the data, they established interpretation criteria by considering the number of statements within each component of the instruments and the number of respondents, thus calculating the

intervals for each interpretation. This research utilized a five-range criteria system, and the researchers summarized the interpretations as stated in Table 3.

The researchers added scores for each part and found the mean and standard deviation scores to check for statistical differences among TPACK indicators. The outcomes are presented in Table 4. As presented in Table 4, the research findings reveal the level of technological knowledge in the respective domains for EFL pre-service teachers (N=55). The study divided the evaluation into four key aspects: technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and TPACK. The participants' technological knowledge for integrating AI-powered tools into their EFL teaching practices can be described by examining the above aspects. There are five indicators in TK, which are the first aspect. The mean scores in this aspect show that the pre-service teachers have a moderate level of TK. Moreover, TPK is the second aspect of this questionnaire, with seven indicators. The findings indicate that pre-service teachers have a moderate level of TPK. The third aspect is TCK, and it has four indicators. The level of TCK among pre-service teachers in this study is moderate. Lastly, TPACK is the final aspect, which has four indicators. The findings reveal that pre-service teachers have a moderate level of TPACK. Therefore, this study's technological knowledge level is moderate in TK, TPK, TCK, and TPACK.

Table 3. Interpretation criteria

Mean range	Criteria
4.3 to 5.0	Very high
3.5 to 4.2	High
2.7 to 3.4	Moderate
1.9 to 2.6	Low
1.0 to 1.8	Very low

Table 4. EFL pre-service teachers' levels of technological knowledge in the respective domains of TPACK toward integrating AI-powered tools

No.	Statement	Total respondents	Mean	SD	Criteria
	EFL pre-service teachers' TK				
1	I have experience using some AI-based tools to complete tasks.	55	3.39	0.96	Moderate
2	I understand how to use AI-based tools in my day-to-day activities.	55	3.36	0.97	Moderate
3	I am aware of how to use speech or text to initiate a task for AI-based technologies.	55	3.38	0.77	Moderate
4	I know enough to operate AI-based tools.	55	3.36	0.77	Moderate
5	I am familiar with AI-based tools and their technical capacities.	55	3.25	0.97	Moderate
	EFL pre-service teachers' TPK				
6	I am aware of the educational value that AI-based tools bring to my field of teaching.	55	3.38	0.88	Moderate
7	I am able to assess how beneficial feedback from AI-based tools is for instruction and learning.	55	3.38	0.92	Moderate
8	I can choose AI-based resources so that students can use what they've learned.	55	3.32	0.97	Moderate
9	I am aware of how to track students' progress using AI-based technologies.	55	3.36	0.91	Moderate
10	I can provide immediate feedback by interpreting messages from AI-based tools.	55	3.23	0.91	Moderate
11	I can see how AI-based tools might alert (or notify) users to support their learning.	55	3.37	0.72	Moderate
12	I am qualified to choose AI-based resources that keep students motivated.	55	3.34	0.91	Moderate
	EFL pre-service teachers' TCK				
13	I can look up instructional materials in my field of teaching using AI-based tools.	55	3.34	0.74	Moderate
14	I am aware that experts in my field of teaching use a variety of AI-based tools.	55	3.25	0.97	Moderate
15	AI-based tools can help me comprehend the material in my field of teaching more thoroughly.	55	3.38	0.81	Moderate
16	I am proficient in using my field-specific AI tools.	55	3.36	0.93	Moderate
	EFL pre-service teachers' TPACK				
17	I am proficient in using various AI-based tools for adaptive feedback in my field of teaching.	55	3.21	0.90	Moderate
18	I am knowledgeable about using various AI-based tools for personalized learning in my field of teaching.	55	3.19	0.87	Moderate
19	I am proficient in using various AI-based tools for real-time feedback when I am teaching my field.	55	3.19	0.93	Moderate
20	I am able to teach a subject with a variety of teaching techniques and AI-based tools.	55	3.21	0.92	Moderate
21	I am able to deliver lessons that effectively integrate my instructional materials, AI-powered resources, and pedagogical techniques.	55	3.21	0.92	Moderate
22	Among my colleagues, I can assume a leading role in incorporating AI-based tools into our field of education.	55	3.21	0.84	Moderate
23	I can use a variety of AI-based tools to keep an eye on my students' progress while I'm teaching.	55	3.28	0.88	Moderate

A previous study echoes these findings, stating that EFL pre-service teachers demonstrated a moderate level in TK, TCK, TPK, and TPACK [37]. They tend to outperform in-service EFL teachers in the TPACK framework due to differences in exposure and training with AI-powered tools. As part of the younger generation, they enter teacher education programs with a natural inclination for technology and receive specialized training in integrating AI tools [32]. However, these findings oppose earlier research that claimed that preservice teachers had a high level of technology in the respective domains, such as TK, TPK, TCK, and TPACK [38], [39]. Furthermore, EFL pre-service teachers in this study have the opportunity to enhance their technological knowledge for integrating AI-powered tools into education.

Based on the discussion above, there is an opportunity to expand teachers' technological knowledge by integrating AI-powered tools into the educational context. They can participate in workshops, tutorials, and mentorship programs as part of their professional development to enhance skills related to integrating technology into teaching strategies [40]. These initiatives empowered pre-service teachers to enable them to integrate AI-powered tools for teaching-learning activities. Teachers can expand their ability to choose the relevant AI-powered tools and integrate them to help students achieve learning targets because TPACK is crucial in crafting effective technology-based instruction [3]. Additionally, their understanding of TPACK can influence pre-service teachers in choosing the most effective AI-powered tools, solving problems in using AI, accessing diverse and high-quality resources, and integrating them into their teaching practices.

3.2. The strategy of EFL pre-service teachers to advance their technological knowledge in the respective domains of TPACK toward integrating AI-powered tools

The thematic analysis functioned as a tool for researchers to investigate repetitive patterns in the research data. Researchers systematically documented these patterns through coded data and organized them into a thematic analysis. During the interview sessions, a prevailing theme emerged, as research respondents consistently provided feedback on their endeavors to enhance their technological knowledge. Based on the in-depth interview analysis, researchers identified four sub-themes. As outlined below, these sub-themes were associated with the strategies employed by EFL pre-service teachers, as stated in Figure 1.
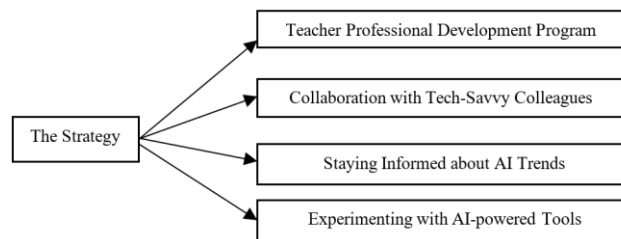

Figure 1. The strategy of EFL pre-service teachers to advance their level of technological knowledge

One strategy for advancing the technological knowledge of EFL pre-service teachers was through a proper TPD program. This strategy was obtained after researchers carried out a thematic analysis. Respondent 1 supported this argument by responding in the quote:

"Engaging in the TPD program is vital for advancing my technological knowledge. My academic program frequently hosts TPD sessions with workshops. A recent session spotlighted the AI tool Wordly, emphasizing it is educational applications. The discussions not only unveiled Wordly's features but also underscored its potential in educational settings."

According to the answer from respondent 1, their academic program frequently conducted the TPD program, consisting of workshops and training sessions. The focus of a recent workshop was on an AI-powered tool called Wordly. Wordly was designed for transcribing conversations in various meeting formats. The workshop informed participants about Wordly's features and featured its potential applications in educational contexts. They have learned how to use Canva (AI Graphic Design), ChatGPT (AI-Language Model), Tome (AI presentation maker), and EssayGrader (AI-powered grading assistant) by attending other workshops. A previous study claims that participants in TPD programs have learning opportunities to develop new AI-related abilities and capabilities [32]. Participants in this study can develop their technological knowledge in using AI-power tools by participating in workshops and seminars as part of TPD programs in their study program. They can study using Canva, ChatGPT, Tome, and EssayGrader in educational settings. Zhang and Fang [12] conducted a study examining the role of professional development in students' achievement and found that

teachers who participate in professional development programs gain cutting-edge teaching techniques critical for fostering students' accomplishments.

Additionally, the researchers found the second strategy after conducting the thematic analysis. The researchers revealed that teachers can improve their ability to use AI-powered tools by collaborating with their teach-savvy colleagues. Respondent 2 supported this argument in the statement:

> "In our academic group, we know how important it is to learn from each other and share our knowledge. Working with coworkers who are very knowledgeable about AI has been very helpful. This collaboration has helped me gain useful knowledge for using Tome through casual conversations, group projects, and sharing of personal experiences".

According to the interview above, she stated that collaboration with tech-savvy colleagues is a strategy for expanding their technological knowledge. She can share ideas about new AI-powered tools, such as Tome, that help teachers make educational content. Tome is an AI-powered tool for creating professional presentations. Many template presentations can attract their students. They can expand their skills in operating AI-powered tools by exchanging ideas with their colleagues. They can also ask about how to solve problems while using these tools. The findings from previous studies consistently demonstrated that teachers recognized the importance of collaboration strategies for developing their technological knowledge in related domains [34], [41], [42]. Similarly, collaboration provides educators quick access to material, accelerated learning, and fun opportunities to improve technological proficiency. Educators could incorporate AI-driven tools into their teaching practices by using collaboration regularly. In the present study, the collaboration among teachers was expected to play a significant role in assisting participants in enhancing their understanding of TK, TPK, TCK, and TPACK.

EFL pre-service teachers employed a staying informed strategy about AI trends to enhance their knowledge of AI trends. This answer is the third strategy found in this study. Respondent 3 added another statement that supports this finding:

> "I like watching YouTube to find tutorials for using AI-powered tools. These tutorials help me for mastering these tools for educational purposes. Additionally, I also watch TikTok and Instagram Reels for similar content because these platforms provide shorter durations that efficiently convey valuable content on AI." (Respondent 3)

Based on the above interview results, various ways exist to stay updated on AI trends and tutorials for advancing teachers' technological knowledge. Respondent 3 said that she likes watching videos on YouTube, TikTok, and Instagram for updating information about AI-powered tools. These platforms provide new information about how to use AI-powered tools, benefits, drawbacks, and subscription-free. Previous empirical research found that teachers who intended to stay informed about new technology could expand their TPACK competencies, including technological knowledge in the respective domains [43], [44]. In this current study, EFL Pre-service teachers acquire AI information by exploring social media platforms like YouTube, TikTok, and Instagram Reels. They benefited from their strategies as they perceived many relevant sources for integrating AI-powered tools into teaching practice. Updating information from many sources might include introducing educational technology, innovative teaching approaches, or efficient classroom management strategies to maximize its positive effects [45].

The final strategy for advancing their technological knowledge is experimenting with AI-powered tools. The researchers found this strategy after analyzing using thematic analysis. Respondent 4 stated a similar idea to support this finding in the text:

> "I enjoy using AI-powered tools to produce my educational content. ChatGPT prompts inspire instructional presentation materials. I practice Canva by making presentations, movies, and posters. Canva's free educator access to premium capabilities in this AI visual design platform is invaluable."

Additionally, respondent 4 highlighted the importance of these experiments in fostering creativity and innovation in educational materials. She explored dynamic ways to generate ideas and content for teaching by experimenting with ChatGPT. She also explores the use of Canva to create visually engaging materials, such as posters, short videos, and presentation slides. These explorations facilitate the teachers' development of more interactive instructional content and create stimulating student learning experiences. A previous study echoes the current findings, which stated that experimentation with ChatGPT was fundamental for preparing students with the indispensable ability to thrive in a future dominated by AI [18]. To this end, teachers could advance their understanding of integrating AI-powered tools by gaining and expanding hands-on experience

with these tools. The next generation of educators could use these technologies in classrooms effectively by incorporating AI tools into teacher training programs [31]. Lack of engagement in AI tools might put them at a competitive disadvantage in the job market compared to those with extensive exposure and practical experience. Therefore, it was crucial to establish an educational framework that integrates and assesses these tools for the benefit of EFL pre-service teachers.

4.   CONCLUSION

Based on the findings and discussion, this study revealed the level of technological knowledge in the respective domains for EFL pre-service teachers using AI-powered tools. The researchers employed four evaluation domains for this current research: TK, TPK, TCK, and TPACK. The findings reveal that pre-service teachers have a moderate level across four indicators (TK, TPK, TCK, and TPACK). Furthermore, EFL pre-service teachers in this study had the opportunity to enhance their technological knowledge for integrating AI-powered tools into education. Meanwhile, this study examined how EFL pre-service teachers advanced their technological knowledge using AI-powered tools in the Indonesian context. The researchers employed thematic analysis as data analysis and four key strategies to advance their technological knowledge in the respective domains. They engage in TPD programs, collaborate with tech-savvy colleagues, stay informed about AI trends, and experiment with AI-powered tools.

This current study is significant to English teachers and stakeholders in Indonesia to take teachers' competencies in integrating AI-powered tools into account. The teachers' competencies can influence the quality of students' education. EFL pre-service teachers must be well-prepared to integrate AI-powered tools into teaching practice for their future careers. Thus, teachers must be aware of their competencies and frequently enhance their knowledge to support their knowledge in technology integration. On the other hand, this study has certain limitations. EFL pre-service teachers were selected purposively as participants in this study without including in-service teachers. Thus, the research results cannot be generalized to a wider population of EFL teachers. Furthermore, the topic of AI is too broad to study. To tackle this issue, the next research could concentrate on certain AI applications such as AI graphics design, AI chatbots, AI grading systems, and AI speech-text recognition. Implementing this focused strategy would provide a more detailed examination of the influence of AI tools in education.

REFERENCES

[1]   M. Metaria and B. Y. Cahyono, "EFL students' engagement in the post-pandemic teaching: Does technology matter?," *Journal on English as a Foreign Language*, vol. 14, no. 1, pp. 26–47, 2024.
[2]   W. Admiraal *et al.*, "Preparing pre-service teachers to integrate technology into K–12 instruction: evaluation of a technology-infused approach," *Technology, Pedagogy and Education*, vol. 26, no. 1, pp. 105–120, Jan. 2017, doi: 10.1080/1475939X.2016.1163283.
[3]   M. J. Koehler and P. Mishra, "What is technological pedagogical content knowledge?," *Contemporary Issues in Technology and Teacher Education*, vol. 9, no. 1, pp. 1–10, 2009.
[4]   S. Syamdianita and B. Y. Cahyono, "The EFL pre-service teachers' experiences and challenges in designing teaching materials using TPACK framework," *Studies in English Language and Education*, vol. 8, no. 2, pp. 561–577, May 2021, doi: 10.24815/siele.v8i2.19202.
[5]   B. Y. Cahyono, O. D. Kurnianti, and I. Mutiaraningrum, "Indonesian EFL teachers' application of tpack in in-service education teaching practices," *International Journal of English Language Teaching*, vol. 4, no. 5, pp. 16–30, 2016.
[6]   D. Miranty, U. Widiati, B. Y. Cahyono, and T. I. Suzila, "Automated writing evaluation tools for Indonesian undergraduate English as a foreign language students' writing," *International Journal of Evaluation and Research in Education (IJERE)*, vol. 12, no. 3, pp. 1705–1715, Sep. 2023, doi: 10.11591/ijere.v12i3.24958.
[7]   G. Kurt, P. Mishra, and Z. Kocoglu, "Technological pedagogical content knowledge development of Turkish pre-service teachers of English," in *Society for Information Technology and Teacher Education International Conference*, 2013, pp. 5073–5077.
[8]   Z. Koçoğlu, "Exploring the technological pedagogical content knowledge of pre-service teachers in language education," *Procedia - Social and Behavioral Sciences*, vol. 1, no. 1, pp. 2734–2737, 2009, doi: 10.1016/j.sbspro.2009.01.485.
[9]   A. Aşık, S. Köse, G. Yangın Ekşi, G. Seferoğlu, R. Pereira, and M. Ekiert, "ICT integration in English language teacher education: insights from Turkey, Portugal and Poland," *Computer Assisted Language Learning*, vol. 33, no. 7, pp. 708–731, Sep. 2020, doi: 10.1080/09588221.2019.1588744.
[10]   M. G. Saudelli and K. Ciampa, "Exploring the role of TPACK and teacher self-efficacy: an ethnographic case study of three iPad language arts classes," *Technology, Pedagogy and Education*, vol. 25, no. 2, pp. 227–247, Mar. 2016, doi: 10.1080/1475939X.2014.979865.
[11]   B. Y. Cahyono, P. Ardi, Y. N. Siwa, R. Sari, and R. A. Gestanti, "EFL teachers' technological pedagogical knowledge (TPK) and ecological agency in responding to the differentiated learning policy in Indonesia," *Journal of Research in Applied Linguistics*, vol. 14, no. 2, pp. 84–100, 2023.

[12] M. Zhang and X. Fang, "Exploring university EFL teachers' technological pedagogical content knowledge and teacher efficacy in technology-integrated flipped classroom," *SAGE Open*, vol. 12, no. 3, Jul. 2022, doi: 10.1177/21582440221116105.

[13] S. Pokrivcakova, "Preparing teachers for the application of AI-powered technologies in foreign language education," *Journal of Language and Cultural Education*, vol. 7, no. 3, pp. 135–153, Dec. 2019, doi: 10.2478/jolace-2019-0025.

[14] Q.-K. Fu, D. Zou, H. Xie, and G. Cheng, "A review of AWE feedback: types, learning outcomes, and implications," *Computer Assisted Language Learning*, vol. 37, no. 1–2, pp. 179–221, Jan. 2024, doi: 10.1080/09588221.2022.2033787.

[15] D. S. McNamara, S. A. Crossley, and R. Roscoe, "Natural language processing in an intelligent writing strategy tutoring system," *Behavior Research Methods*, vol. 45, no. 2, pp. 499–515, Jun. 2013, doi: 10.3758/s13428-012-0258-1.

[16] W. L. Johnson, "Serious use of a serious game for language learning," *International Journal of Artificial Intelligence in Education*, vol. 20, no. 2, pp. 175–195, 2010.

[17] G. Stockwell, "Vocabulary on the move: investigating an intelligent mobile phone-based vocabulary tutor," *Computer Assisted Language Learning*, vol. 20, no. 4, pp. 365–383, Oct. 2007, doi: 10.1080/09588220701745817.

[18] S. Grassini, "Shaping the future of education: exploring the potential and consequences of AI and ChatGPT in educational settings," *Education Sciences*, vol. 13, no. 7, pp. 692–705, Jul. 2023, doi: 10.3390/educsci13070692.

[19] D. Grimes and M. Warschauer, "Utility in a fallible tool: a multi-site case study of automated writing evaluation," *The Journal of Technology, Learning, and Assessment*, vol. 8, no. 6, 2010.

[20] R. D. Roscoe and D. S. McNamara, "Writing pal: feasibility of an intelligent writing strategy tutor in the high school classroom.," *Journal of Educational Psychology*, vol. 105, no. 4, pp. 1010–1025, Nov. 2013, doi: 10.1037/a0032340.

[21] S. J. H. Yang, H. Ogata, T. Matsui, and N.-S. Chen, "Human-centered artificial intelligence in education: Seeing the invisible through the visible," *Computers and Education: Artificial Intelligence*, vol. 2, 2021, doi: 10.1016/j.caeai.2021.100008.

[22] M. AbdAlgane and K. A. J. Othman, "Utilizing artificial intelligence technologies in Saudi EFL tertiary level classrooms," *Journal of Intercultural Communication*, vol. 23, no. 1, pp. 92–99, Mar. 2023, doi: 10.36923/jicc.v23i1.124.

[23] X. An *et al.*, "Modeling English teachers' behavioral intention to use artificial intelligence in middle schools," *Education and Information Technologies*, vol. 28, no. 5, pp. 5187–5208, May 2023, doi: 10.1007/s10639-022-11286-z.

[24] S. Choi, Y. Jang, and H. Kim, "Influence of pedagogical beliefs and perceived trust on teachers' acceptance of educational artificial intelligence tools," *International Journal of Human–Computer Interaction*, vol. 39, no. 4, pp. 910–922, Feb. 2023, doi: 10.1080/10447318.2022.2049145.

[25] Y. Du and H. Gao, "Determinants affecting teachers' adoption of AI-based applications in EFL context: an analysis of analytic hierarchy process," *Education and Information Technologies*, vol. 27, no. 7, pp. 9357–9384, Aug. 2022, doi: 10.1007/s10639-022-11001-y.

[26] M. B. Ulla, W. F. Perales, and S. O. Busbus, "' To generate or stop generating response': Exploring EFL teachers' perspectives on ChatGPT in English language teaching in Thailand," *Learning: Research and Practice*, vol. 9, no. 2, pp. 168–182, Jul. 2023, doi: 10.1080/23735082.2023.2257252.

[27] Marzuki, U. Widiati, D. Rusdin, Darwin, and I. Indrawati, "The impact of AI writing tools on the content and organization of students' writing: EFL teachers' perspective," *Cogent Education*, vol. 10, no. 2, Dec. 2023, doi: 10.1080/2331186X.2023.2236469.

[28] D. N. Arini, F. Hidayat, A. Winarti, and E. Rosalina, "Artificial intelligence (AI)-based mobile learning in ELT for EFL learners: the implementation and learners' attitudes," *International Journal of Educational Studies in Social Sciences (IJESSS)*, vol. 2, no. 2, Apr. 2022, doi: 10.53402/ijesss.v2i2.40.

[29] R. Rusmiyanto, N. Huriati, N. Fitriani, N. K. Tyas, A. Rofi'i, and M. N. Sari, "The role of artificial intelligence (AI) in developing English language learner's communication skills," *Journal on Education*, vol. 6, no. 1, pp. 750–757, May 2023, doi: 10.31004/joe.v6i1.2990.

[30] I. G. A. L. P. Utami and I. G. N. A. W. Mahardika, "Grammarly and grammatical errors reduction: A case for non-native English teachers' professional learning," *International Journal of Language Education*, vol. 7, no. 2, Jun. 2023, doi: 10.26858/ijole.v7i2.46431.

[31] T. Adiguzel, M. H. Kaya, and F. K. Cansu, "Revolutionizing education with AI: exploring the transformative potential of ChatGPT," *Contemporary Educational Technology*, vol. 15, no. 3, Jul. 2023, doi: 10.30935/cedtech/13152.

[32] C. Zhang, J. Schießl, L. Plößl, F. Hofmann, and M. Gläser-Zikuda, "Acceptance of artificial intelligence among pre-service teachers: A multigroup analysis," *International Journal of Educational Technology in Higher Education*, vol. 20, no. 1, Sep. 2023, doi: 10.1186/s41239-023-00420-7.

[33] J. W. Creswell, *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson; 4th edition, 2012.

[34] I. Celik, "Towards intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education," *Computers in Human Behavior*, vol. 138, p. 107468, Jan. 2023, doi: 10.1016/j.chb.2022.107468.

[35] G. A. Ferguson and Y. Takane, *Statistical analysis in psychology and education*. McGraw-Hill, Inc.; 6th edition, 1989.

[36] D. Harrington, *Confirmatory factor analysis*. Oxford: Oxford University Press, 2009.

[37] Y. Wang, X. Gu, and S. Liu, "The investigation and analysis of pre-service teachers TOWARD TPACK competencies," *Open Journal of Social Sciences*, vol. 08, no. 12, pp. 327–339, 2020, doi: 10.4236/jss.2020.812027.

[38] P. Luik, M. Taimalu, and R. Suviste, "Perceptions of technological, pedagogical and content knowledge (TPACK) among pre-service teachers in Estonia," *Education and Information Technologies*, vol. 23, no. 2, pp. 741–755, Mar. 2018, doi: 10.1007/s10639-017-9633-y.

[39] A. Sariçoban, I. Tosuncuoglu, and Ö. Kirmizi, "A technological pedagogical content knowledge (TPACK) sssessment of pre-service EFL teachers learning to teach English as a foreign language," *Journal of Language and Linguistic Studies*, vol. 15, no. 3, pp. 1122–1138, 2019.

[40] H. Khodabakhshzadeh, M. Hosseinnia, H. A. Moghadam, and F. Ahmadi, "EFL teachers' creativity and their teaching's effectiveness: A structural equation modelling approach," *International Journal of Instruction*, vol. 11, no. 1, pp. 227–238, Jan. 2018, doi: 10.12973/iji.2018.11116a.

[41] J. Tondeur, R. Scherer, F. Siddiq, and E. Baran, "Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): A mixed-method study," *Educational Technology Research and Development*, vol. 68, no. 1, pp. 319–343, Feb. 2020, doi: 10.1007/s11423-019-09692-1.

[42] Y.-F. Yeh, K. K. H. Chan, and Y.-S. Hsu, "Toward a framework that connects individual TPACK and collective TPACK: A systematic review of TPACK studies investigating teacher collaborative discourse in the learning by design process," *Computers & Education*, vol. 171, Oct. 2021, doi: 10.1016/j.compedu.2021.104238.

[43] L. Lai Wah and H. Hashim, "Determining pre-service teachers' intention of using technology for teaching English as a second language (ESL)," *Sustainability*, vol. 13, no. 14, Jul. 2021, doi: 10.3390/su13147568.

[44] S. Bardakcı and M. F. Alkan, "Investigation of Turkish preservice teachers' intentions to use IWB in terms of technological and pedagogical aspects," *Education and Information Technologies*, vol. 24, no. 5, pp. 2887–2907, Sep. 2019, doi: 10.1007/s10639-019-09904-4.

[45] A. Cirocki and T. S. C. Farrell, "Professional development of secondary school EFL teachers: Voices from Indonesia," *System*, vol. 85, Oct. 2019, doi: 10.1016/j.system.2019.102111.

BIOGRAPHIES OF AUTHORS

Tommy Hastomo is a lecturer at STKIP PGRI Bandar Lampung, Lampung. He is a doctoral student in the Department of English at Language Universitas Negeri Malang. His research interest is ICT in ELT. He can be contacted at email: tomhas182@gmail.com.

Berlinda Mandasari is a lecturer at Universitas Teknokrat Indonesia, Lampung. She is a doctorate student at the Department of English Language at Universitas Negeri Malang. Her research interests are teacher professional development, English language teacher education, and technology in English language teaching. She can be contacted at email: Berlinda@teknokrat.ac.id.

Utami Widiati is a faculty member of the Department of English at Universitas Negeri Malang (UM). She has done great research and written significantly in TEFL, curriculum and material development, SLA, and teacher professional development. She has authored secondary school English textbooks required by the Indonesian government and works as a pre-service and in-service teacher trainer. She can be contacted at email: utami.widiati.fs@um.ac.id.