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Exploring the relationship between teachers' competencies in AI-TPACK and digital proficiency

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Abstract
In recent years, there has been a growing emphasis on integrating Artificial Intelligence (AI) applications in educational settings. As a result, it is essential to assess teachers' competencies in Technological, Pedagogical, and Content Knowledge (TPACK) as it pertains to AI and examine the factors that influence these competencies. This study aims to analyze the impact of digital proficiency on teachers' AI-TPACK competencies. The study utilized a correlational survey model and involved 401 teachers from various provinces and departments in Turkey. The data collection tools included a personal information form, an AI-TPACK scale, and a digital proficiency scale. The collected data were analyzed using structural equation modeling. The research findings revealed that teachers' AI-TPACK competencies were below average, whereas their levels of digital proficiency were above average. Furthermore, a significant relationship between teachers' AI-TPACK and digital proficiency levels was identified, with digital proficiency as a significant predictor of AI-TPACK competencies. Based on the research findings, recommendations for future studies are provided.

Keywords Artificial intelligence · AI-TPACK · Digital proficiency · Teachers

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1 Introduction

In the past decade, there has been remarkable progress in machine learning and artificial intelligence (AI) in learning algorithms and information processing techniques. AI, which falls within the realm of information technology, aims to replicate various cognitive abilities demonstrated by humans, such as reasoning, comprehension, generalization, inference, learning, and multitasking (Gondal, 2018; Jia et al., 2023; Russell & Norvig, 2021). As a scientific discipline, AI consistently evolves by investigating human intelligence and brain functionality. Through problem-solving, reasoning, and learning, AI is transforming our approach to information analysis and decision-making.

AI-based applications have significantly expanded educational opportunities for students and educators alike. The utilization of these applications, such as intelligent chatbots, control panels, and automated assessment systems, has gained considerable popularity within educational environments (Zhang et al., 2023). As a result, many countries are now establishing policies and dedicating resources to integrating AI applications into education (Ma & Lei, 2024). When analyzing the Turkish education system, it becomes apparent that there has been an increase in research on integrating AI into education since 2010 (Akdeniz & Özdinç, 2021). A systematic study by Akdeniz and Özdinç (2021) found that intelligent teaching systems are the most preferred application of AI in Turkey. Furthermore, in light of the growing popularity of generative AI in the present era, the Turkish Ministry of National Education (MoNE) has organized a forum to evaluate the processes involved in utilizing AI technology in education. The upcoming "AI Applications Trainer Training Course," hosted by the esteemed Innovation and Educational Technologies team, aims to provide a comprehensive exploration of AI tools, machine learning, and deep learning for teachers. In this particular context, it can be argued that concerted efforts have been made to implement AI applications in the field of education in Turkey.

AI and machine learning are emerging as alternative tools to address educational inequalities (Forero-Corba & Bennasar, 2024). For instance, chat agents can be highly effective in providing answers to theoretical questions that do not require creativity from students, subsequently increasing student motivation (Forero-Corba & Bennasar, 2024; Rahiman & Kodikal, 2024). Additionally, AI-supported learning approaches are employed to identify students' weaknesses and provide personalized learning environments (Jia et al., 2023; Nja et al., 2023; Rahiman & Kodikal, 2024; Shin, 2022; Song & Wang, 2020; Zhang et al., 2023). Furthermore, AI-supported teaching applications enable course adaptation according to students' preferences, early identification of at-risk students, and prompt intervention (Mao et al., 2024; Rahiman & Kodikal, 2024).

Consequently, integrating AI applications in teaching is expected to bring about a significant transformation in teaching processes and evaluation methods (Jia et al., 2023). Efficient AI tools can rapidly perform various operations, such as generating text-based responses, creating virtual images, and producing music from text (Mao et al., 2024). These tools are embedded in software like word processors or presentation slides (Lodge et al., 2023). In terms of evaluation, AI-supported applications can provide instant and practical feedback to students. This opportunity allows for

reduced teacher workload and a greater focus on higher-level thinking skills during lessons (Mao et al., 2024). AI also assists educators in identifying areas for potential improvement in their teaching abilities while presenting them with tailored professional development prospects (Rahiman & Kodikal, 2024). Preparing educators for AI-enabled education is a crucial challenge in seamlessly integrating AI into forthcoming educational settings (Zhang et al., 2023). Therefore, teachers must possess technological and pedagogical knowledge specific to these applications to effectively integrate AI applications into their learning environments (Antonenko & Abramowitz, 2023; Lodge et al., 2023; Ning et al., 2024).

2 AI-TPACK

Nowadays, it is imperative to stay abreast of the latest scientific and technological advancements across various disciplines. Education and training play a pivotal role in accomplishing this objective. Consequently, it is crucial to incorporate Information and Communication Technologies (ICT) into the educational system, ensuring their alignment with a robust framework and facilitating their effective implementation. Consequently, possessing Technological Pedagogical Content Knowledge (TPACK) competencies has become indispensable for educators.

TPACK provides a comprehensive framework for comprehending the essential knowledge that educators require to utilize technology in their teaching practices effectively (Mishra & Koehler, 2006). This framework builds upon the concept of pedagogical content knowledge by incorporating technological knowledge (See Fig. 1). Educators with advanced levels of TPACK competence can seamlessly integrate their technological expertise with their pedagogical and content knowledge, thereby enhancing the learning process. The TPACK framework emphasizes the dynamic and interconnected relationships among pedagogy, content, and technology (Koehler & Mishra, 2009). Content knowledge refers to educators' understanding of the subject matter they teach, and this component influences the integration of technology in instruction. Pedagogical knowledge involves educators' understanding of instructional and learning processes. Technological knowledge encompasses educators' proficiency in using various hardware, software, and systems, as well as their ability to stay up to date on emerging technologies.

AI's influential impact on education necessitates a critical reassessment of the interconnectedness between technology, pedagogy, and content (Ning et al., 2024). In recent times, researchers have developed the AI-TPACK framework to facilitate the integration of AI-based applications into educators' teaching practices (Celik, 2023; Lodge et al., 2023). In essence, the AI-TPACK framework serves as a tool to evaluate the competence of teachers in utilizing appropriate AI tools to effectively achieve educational objectives within a specific domain while also aligning with pedagogical strategies. The competence of teachers in TPACK plays a significant role in nurturing AI literacy (Velander et al., 2023). Despite the opportunities of AI-based technologies for teaching and learning, they also involve ethical issues regarding personal data and learner autonomy (Nguyen et al., 2023; Velander et al., 2023). Because the data is biased, the output of AI algorithms will likely become biased. For example,

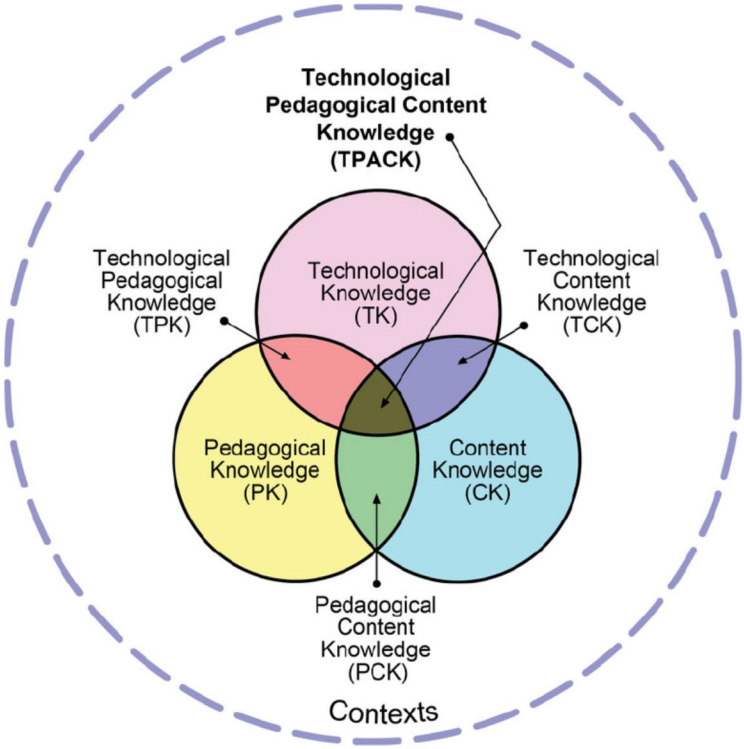


Fig. 1 The TPACK framework (Mishra & Koehler, 2006)

early warning notifications from a dashboard may be counterintuitive or pedagogically meaningless. Teachers must justify the decision to use AI-based tools. In addition, those who utilize AI technology must possess a profound sense of responsibility toward safeguarding student privacy and fostering ethical awareness concerning the appropriate utilization of AI technology (Ma & Lei, 2024). In particular, AI-based tools should be used to promote equality among different groups of students rather than discriminating against any subgroup of students (Lodge et al., 2023).

The AI-TPACK framework consists of five fundamental components, namely AI-Technological Knowledge (AI-TK), AI-Technological Pedagogical Content Knowledge (AI-TCK), AI-Technological Pedagogical Knowledge (AI-TPK), and Ethics. Figure 2 offers a comprehensive overview of these components.

3 Digital proficiency

The rapid development of Information Technology (IT) has had a significant impact on people's thoughts and behaviors in various contexts, including education (Huang et al., 2021). The term "digital native" was coined to explain the differences in technology usage among different generations (Prensky, 2001). There are two distinct

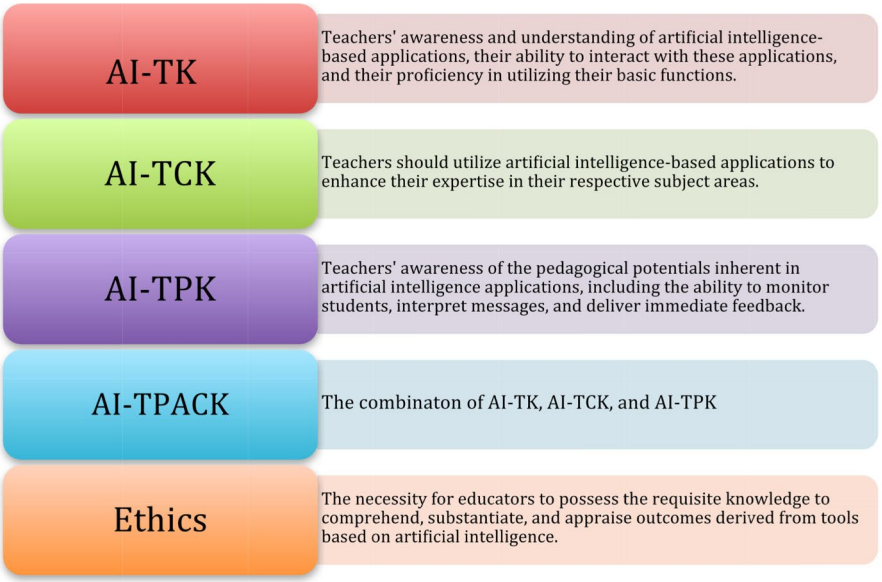
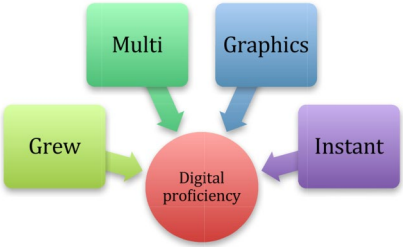


Fig. 2 The components of AI-TPACK (Celik, 2023)

groups: digital immigrants and digital natives. Digital immigrants are individuals who were born before the advent of IT, while digital natives have been exposed to various IT activities, such as Internet browsing, online gaming, and online social networking, at an earlier and more extensive stage (Wang et al., 2019). These individuals possess quick information retrieval, multitasking abilities, a preference for visual content over written materials, and constant connectivity to different networks (Çoklar et al., 2017; Kabakci Yurdakul, 2018). Helsper and Eynon (2010) argued that the degree of digital nativity depends not only on age but also on the diversity of technology usage, personal experience, digital self-efficacy, and education. Digital literacy, digital fluency, and digital proficiency can also be used to clarify the notion of "digital nativity." These terms emphasize the importance of acquiring the necessary skills and competencies to navigate digital environments rather than relying solely on being born in the digital era. This study chose the term "digital proficiency" instead of "digital nativity" as it carries a somewhat outdated connotation.

Fig. 3 The dimensions of digital proficiency (Teo et al., 2016)



In this particular context, Teo (2013) developed a model addressing the individual aspects of digital proficiency (see Fig. 3). This model encompasses dimensions such as familiarity with technology, comfort with multitasking, reliance on visual communication, and a preference for instant gratification and rewards (Teo, 2013). The dimension of "familiarity with technology" refers to the variations among individuals regarding their experience and habits in using information technology. The second dimension, "comfort with multitasking," reflects differences in individuals' ability to engage in and manage multiple tasks simultaneously. For instance, individuals can communicate with their peers through messaging while simultaneously attending to their emails and completing academic tasks. In addition to multitasking, digitally proficient individuals have adopted various communication strategies that rely more on visual elements, such as images and emoticons, rather than text (Huang et al., 2021). Lastly, "preferring instant gratification and rewards" indicates that digitally proficient individuals seek immediate feedback in their communication with others and in accessing information (Teo, 2013; Teo et al., 2016).

Grew: Growing with technology, Mutli: Comfort with multitasking, Graphics: Reliance on graphics for communication, Instant: thriving on instant gratification and rewards.

The rapid development of digital technologies presents challenges for educators. Digital proficiency refers to the natural familiarity and ease with which individuals who grew up in the digital age interact with digital technologies. Younger students generally have more experience and knowledge of technology. At the same time, teachers who did not grow up in a technologically advanced era initially lack the skills to integrate technology into their teaching methods (Tondeur et al., 2017).

Educators must understand that even though students may have specific technological skills, they may still need guidance to effectively use technology for educational purposes. By embracing and utilizing digital technologies, educators improve their proficiency with these tools, bridging the gap between "digital natives" and "digital immigrants" (Huang et al., 2021). In other words, even though most teachers did not grow up in an environment where digital technology was widespread, they can still acquire digital proficient-like characteristics by becoming well-versed in digital technologies through hands-on experience (Huang et al., 2021). Therefore, while young students may not have inherent technology preferences and skills, educators can nurture their preferences and habits by incorporating technology into their teaching methods.

4 AI-TPACK and digital proficiency

To the best of our knowledge, no previous study has investigated the correlation between teachers' AI-TPACK and levels of digital proficiency. However, studies have been conducted in the field exploring the relationship between teachers' or preservice teachers' TPACK competencies and digital proficiency or IT usage. For example, Kabakci Yurdakul and Çoklar (2014) found a positive correlation between the extent of ICT utilization and the TPACK competencies of teacher candidates. Similarly, Kabakci Yurdakul (2018) identified significant positive correlations between teacher

candidates' TPACK competencies and their levels of digital proficiency. This study also found that digital proficiency significantly predicted TPACK competency. In a study by Milutinović (2022), it was observed that digital proficiency had a substantial impact on the intentions of prospective teachers to incorporate technology in their instructional process, particularly concerning their perceived usefulness and ease of use of technology. A study conducted in China discovered that the degree of digital proficiency significantly influenced teachers' perspectives on technology education (Huang, 2023).

It is suggested that digital native teachers acquire skills faster than digital immigrant teachers during the instructional process. Furthermore, digital native teachers are more inclined to view technology education as advantageous and practical (Huang, 2023). Within this context, we can argue that teachers with a higher level of digital proficiency are more predisposed to perceive AI-based technologies as easily manageable and valuable tools in their teaching practices.

5 The purpose of this study

When conducting a literature review, it becomes evident that there is a need for research to investigate the various factors that influence the AI-TPACK competencies of teachers (Chai et al., 2023; Lodge et al., 2023; Ma & Lei, 2024; Zhang et al., 2023). Kim et al. (2021) argue that there is a lack of emphasis on discussions regarding the competencies teachers should possess to effectively integrate AI-based applications into their teaching practices. Research on AI-TPACK is crucial to understanding how AI can enhance the educational process and help educators adapt to the ever-changing technological landscape (Ning et al., 2024). This study aims to analyze the predictive impact of digital proficiency on teachers' AI-TPACK competencies. Therefore, the following hypotheses have been formulated:

Hypothesis 1: There is a positive correlation between digital proficiency and teachers' AI-TPACK competencies.

Hypothesis 2: Digital proficiency significantly predicts teachers' AI-TPACK competencies.

6 Method

The present study employed the correlational survey model, a research paradigm that rigorously examines and analyzes the interrelationships between two or more variables. It is important to note that correlational research does not establish a definitive cause-and-effect relationship; rather, it enables the prediction of one variable based on information obtained from another variable (Creswell, 2012).

6.1 Participants

A total of 401 teachers employed at public schools in various provinces of Turkey willingly participated in the study. The participants were selected using the convenience sampling method. The majority of participants were from Isparta (47.6%), followed by Yozgat (20.4%), and Ankara (8.0%). The average age of the participants was 41.14 (SD = 9.55), ranging from 22 to 64 years. Two percent of the participants fell within the age group of 60 and above. Although teachers from different departments were included, most were primary school teachers. Among the participants, 41.1% were familiar with AI applications, while 58.9% were not. Those familiar with AI applications primarily reported using ChatGPT, Gemini, and Dall-E software.

In Turkey, MoNE has introduced a program known as EBA, which aims to support the implementation of distance learning initiatives. This program is accessible to educators working at the primary and secondary levels, and it encompasses a control panel, a virtual lesson system, and a chat agent, all of which are enhanced by the integration of AI (MoNE, 2020 cited in Celik, 2023). The data utilized in this study was gathered from participants who utilized either the EBA platform or other AI applications. For a comprehensive overview of the participants, please consult Table 1.

Table 1 Demographic profile of the participants

Variable	Subgroups	Frequency	Percent
Gender	Female	252	62,8
	Male	149	37,2
Department	Primary	158	39,4
	Pre-school	45	11,2
	Math	30	7,5
	English	25	6,2
	Turkish	24	6,0
	Science	23	5,7
	Social Studies	18	4,5
	Other (Biology, Geography, etc.)	78	19,5
Education level	Undergraduate	312	77,8
	Postgraduate	77	19,2
	Doctorate	12	3,0
Education level taught	Pre-school education	32	8,0
	Primary education	272	67,8
	Secondary education	97	24,2
Technology proficiency	Low	6	1,5
	Moderate	163	40,6
	High	232	57,9
Daily internet usage	Less than 1 h	30	7,5
	1–3 h	223	55,6
	More than 3 h	148	36,9
EBA usage	Never	31	7,7
	Occasionally	290	72,3
	Frequently	80	20,0
	Total	401	100

6.2 Data collection instruments

The study collected self-reported data using Google Forms, which included a personal information form, the AI-TPACK questionnaire, and the digital proficiency scale. The link to access the instruments was distributed to teachers who willingly volunteered to participate. The introductory section of the form contained detailed information about the research objectives and scope. All participants provided informed consent before participating in the study. In addition, the guidelines of the Helsinki declaration for data confidentiality and ethical principles in human research were followed. To protect privacy, participants were not required to disclose any identifying details, such as their name or school name, when providing personal information. Participation in completing the data collection tool was voluntary. The survey is expected to take approximately 20 min to complete. The personal information form was used to gather participant data, including variables such as age, department, gender, and level of technology utilization.

This study employed the AI-TPACK scale, developed by Celik (2023), to assess teachers' competency in integrating AI applications into the teaching process. The scale comprises 27 items, evaluated on a 7-point Likert scale, and is divided into five subscales: AI-TK, AI-TCK, AI-TPK, AI-TPACK, and Ethics. The Cronbach alpha values for all factors (AI-TK = 0.856, AI-TCK = 0.868, AI-TPK = 0.858, AI-TPACK = 0.895, and Ethics = 0.864) exceeded the threshold of 0.70, indicating satisfactory internal reliability within each factor. Sample items from the sub-dimensions of this scale are as follows: (1) I am familiar with how to interact with AI-based tools in my daily life (AI-TK). (2) I understand the pedagogical benefits of AI-based tools in my teaching field (AI-TPK). (3) I am capable of using AI-based tools to search for educational materials in my teaching field (AI-TCK). (4) I know how to utilize various AI-based tools for adaptive feedback in my teaching field (AI-TPACK). (5) I can evaluate how AI-based tools consider individual differences, such as race and gender, among my students in my teaching (Ethics).

The study utilized the 21-item Digital Proficiency Scale, adapted for Turkish by Teo, Kabakci Yurdakul, and Ursavaş (2016), to assess the digital proficiency of teachers. The scale employs a 7-point Likert-type format, offering response options ranging from (1) Strongly Disagree to (7) Agree. It consists of four distinct dimensions: Growing up with technology, comfort with multitasking, reliance on graphics for communication, and thriving on instant gratification and rewards. The Cronbach alpha values for all factors (Growing up with technology = 0.84, comfort with multitasking = 0.87, reliance on graphics for communication = 0.83, and thriving on instant gratification and rewards = 0.78) were found to exceed the threshold value of 0.70, indicating good internal reliability within each factor. Examples of items from the scale include: (1) I regularly use the computer for various purposes in my daily life. (2) I can listen to music while using the internet for academic purposes. (3) I prefer receiving messages incorporating graphics and symbols. (4) I have a preference for acquiring information that can be promptly applied in my work.

6.3 Data analysis

Descriptive statistics, including measures such as the mean and standard deviation, were employed to determine the levels of AI-TPACK competencies and digital proficiency among the study participants. Based on the collected data, the reliability coefficients of the AI-TPACK and digital proficiency scales were computed as 0.99 and 0.94, respectively.

To investigate the associations between competencies in AI-TPACK and levels of digital proficiency, we employed a structural equation modeling (SEM) approach. This methodological approach enables the identification of endogenous and latent variables in a causal and relational model, guided by a specific theory. Throughout the research process, multiple fit indices were used to evaluate the adequacy of the structural equation model. The predetermined significance level for all analyses was set at 0.05. It is important to note that the skewness and kurtosis values of the data obtained from the research scales fell within the range of -1 to +1, indicating a normal distribution.

The research employed the Pearson Product Moments correlation to examine the relationships between AI-TPACK competencies and digital proficiency. To assess the impact of digital proficiency on AI-TPACK, structural equation modeling was utilized. Specifically, path analysis, along with a confirmatory measurement model and latent variables, was employed for this purpose. Various measures, such as chi-square ($\chi 2$), RMSEA, CFI, TLI, and NFI, were computed throughout the structural equation modeling process. The study's hypothesis was tested using the Maximum Likelihood method with AMOS 26.

7 Findings

7.1 What are the competencies of teachers in AI-TPACK?

The findings regarding the AI-TPACK competencies of teachers are outlined in Table 2. Upon analyzing the data, it is evident that the average score for teachers' AI-TPACK competencies is 3.33. Notably, the overall AI-TPACK levels of teachers were found to be lower than the average. The average scores across all sub-dimensions on the scale are relatively consistent. The dimensions with the highest mean scores are AI-TCK, with a mean of 3.51, and AI-TPK, with a mean of 3.47. On the other hand, the AI-TPACK dimension obtained the lowest average score, standing at 3.22.

Table 2 Descriptive statistics for the AI-TPACK competency scale

	N	Min	Max	Mean	SD
AI-TK	401	1	7	3,26	1,69
AI-TPK	401	1	7	3,47	1,71
AI-TCK	401	1	7	3,51	1,78
AI-TPACK	401	1	7	3,22	1,73
Ethics	401	1	7	3,23	1,72
AI-TPACK (Overall)	401	1	7	3,33	1,66

Table 3 Descriptive statistics for the digital proficiency scale

	N	Min	Max	Mean	SD
Grew	401	1	7	5,19	1,31
Multi	401	1	7	5,11	1,70
Graphic	401	1	7	4,29	1,53
Instant	401	1	7	5,09	1,29
Digital proficiency (Overall)	401	1	7	4,93	1,23

Table 4 Correlations between AI-TPACK competencies and digital proficiency ($n=401$)

Variables	AI-TPACK						Digital Proficiency				
	AI-TK	AI_TPK	AI-TCK	AI-TPACK	Ethics	AI-TPACK (Overall)	Grew	Multi	Graphics	Instant	Digital Proficiency (Overall)
AI-TK	1,00	,871**	,856**	,884**	,836**	,927**	,273**	,330**	,274**	,183**	,327**
AI_TPK		1,00	,936**	,930**	,907**	,972**	,307**	,342**	,295**	,249**	,363**
AI-TCK			1,00	,934**	,930**	,959**	,337**	,353**	,294**	,238**	,370**
AI-TPACK				1,00	,950**	,981**	,306**	,338**	,303**	,226**	,358**
Ethics					1,00	,956**	,321**	,315**	,318**	,224**	,361**
AI-TPACK (Overall)						1,00	,317**	,349	,308**	,238**	,370**

7.2 To what extent are teachers digitally proficient?

Table 3 presents the results concerning the levels of digital proficiency among teachers. The data analysis reveals that the average level of digital proficiency among teachers is 4.93. The dimensions "Growing up with technology" (Mean = 5.19) and "Comfortable with multitasking" (Mean = 5.11) exhibit the highest mean scores. Conversely, the dimension "Reliant on graphics for communication" has the lowest average score of 4.29.

7.3 Is there a correlation between teachers' AI-TPACK competencies and their levels of digital proficiency?

The study utilized the Pearson Product-Moment Correlation to investigate the correlations between teachers' AI-TPACK competencies and scores in digital proficiency. The results are presented in Table 4.

Upon analyzing the data provided in Table 4, it becomes apparent that there are moderate positive correlations between AI-TK, AI-TPK, AI-TCK, AI-TPACK, and the ethical sub-dimensions of AI-TPACK, as well as the sub-dimensions of digital proficiency encompassing factors growing up with technology, comfort with multitasking, relying on visual communication, and thriving on instant gratification and rewards The findings of this study support the conclusion that as teachers' levels of digital proficiency increase, their proficiency in AI-TPACK also improves. Addition-

ally, the results indicate a statistically significant positive correlation between AI-TPACK competencies and digital proficiency, with a correlation coefficient of 0.37 and a p-value < 0.01.

7.4 Does the variable of digital proficiency significantly impact teachers' AI-TPACK competencies?

After establishing significant correlations between AI-TPACK competencies and digital proficiency in the analysis, the study moved forward to examine the predictive influence of digital proficiency levels on teachers' AI-TPACK competencies using structural equation modeling. To accomplish this, an initial confirmatory measurement model was constructed to assess the alignment between AI-TPACK competencies and the digital proficiency model. The visual representation of the model is displayed in Fig. 4. The fit indices for the measurement model can be found in Table 5.

When examining the fit indices of the established model, it was determined that the goodness of fit index satisfied the desired values. The goodness of fit values for the established model are presented in Table 5. Upon examining Fig. 4, it becomes evident that digital proficiency predicts AI-TPACK competencies significantly ($\beta = 0.39$; $p < .01$). This discovery indicates that the level of digital proficiency positively and significantly influences teachers' AI-TPACK competencies.

The total and indirect effects on AI-TK, AI-TPK, AI-TCK, AI-TPACK, Ethics, growing up with technology, being comfortable with multitasking, relying on graphics for communication, and thriving on instant gratification and rewards are presented in Table 6.

8 Results and discussion

Recent studies have indicated that the use of AI-based applications assists educators in evaluating the teaching process and optimizing lesson planning and implementation. Integrating AI into future classrooms presents a significant challenge in effectively preparing teachers for AI-enabled education (Zhang et al., 2023). As a result, enhancing teachers' AI-TPACK competencies to improve their self-efficacy in technology integration has become a prominent topic in K-12 education (Lodge et al., 2023). Enhancing teacher exposure to AI-TPACK is a complex undertaking that necessitates systemic reform, teacher engagement, and substantial resource allocation (Kabakci Yurdakul & Çoklar, 2014).

Limited research has been conducted on teachers' awareness and opinions regarding the implementation of AI applications in the Turkish context. In a survey-based study conducted by Uygun (2024), the perspectives of 74 Turkish teachers on AI were examined. The findings revealed that teachers acknowledged the benefits of AI in terms of educational support, personalized learning, and instructional material development. However, some teachers expressed concerns about the potential negative impact of AI on ethical and creative thinking processes in education. The study also found that teachers' views on AI did not significantly vary based on their years

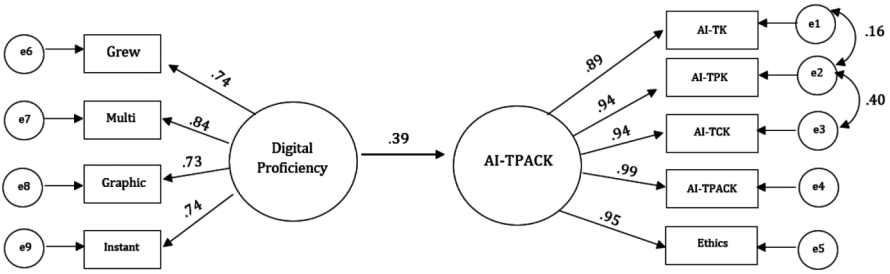


Fig. 4 Confirmatory measurement model for the relationship between AI-TPACK and digital proficiency

Table 5 The goodness of fit indexes for the measurement model

Fit statistics	Model fit values	Criteria for acceptable fit	Reference
χ^2/df	2.74	$0 \leq \chi^2/df \leq 3$	Kline (2005)
RMSEA	0.0.066	$0.05 \leq RMSEA \leq 0.08$	Thompson, 2004
CFI	0.99	$0.95 \leq CFI \leq 0.97$	Tabachnick & Fidell, 2001
TLI	0.98	$0.85 \leq TLI \leq 0.9$	Tabachnick & Fidell, 2001
NFI	0.98	$0.9 \leq NFI \leq 0.95$	Tabachnick & Fidell, 2001

Table 6 Total and indirect effects in Structural Model

	Total effects		Indirect effects
	Digital Proficiency	AI-TPACK	Digital Proficiency
Grew	0.74		
Multi	0.84		
Graphics	0.73		
Instant	0.74		
AI-TK		0.89	0.35
AI-TPK		0.99	0.37
AI-TCK		0.94	0.37
AI-TPACK		0.94	0.39
Ethics		0.89	0.38

of experience or academic discipline. Another qualitative study by Özer et al. (2023) revealed that educators generally hold positive views on using AI applications. These applications are believed to benefit students' academic achievements and the development of critical thinking skills. Moreover, AI technology is seen as a valuable tool for improving classroom management and simplifying student evaluations. However, teachers have expressed concerns about potential negative consequences related to the availability of AI technology. These concerns include unequal access, financial burdens, and a lack of emotional engagement associated with AI applications. In a phenomenological study conducted by Seyrek et al. (2024), a total of 28 classroom teachers participated. The study found that teachers used AI applications for different purposes, including question preparation, content creation, and activity development. Furthermore, the research showed that young teachers had a strong preference for

using AI applications. The study also found a positive correlation between the extent and frequency of AI usage. However, teachers argue that AI has drawbacks when it comes to hampering creativity and jeopardizing data security. These limited studies indicate that teachers in Turkey have positive attitudes towards artificial intelligence technologies.

The results of this study indicate that Turkish teachers' AI-TPACK competencies were below average. To be more specific, teachers exhibit a lack of competence when it comes to integrating AI-based applications into the educational process. There is still limited research on how teachers comprehend AI technologies, particularly its integration in the classroom. One of these limited studies, Antonenko and Abramowitz (2023) study findings demonstrate that teachers tend to incorporate AI tools and applications into their instructional methodologies. Furthermore, Velander et al. (2023) discovered that teachers primarily acquire their understanding of AI through informal learning, often leading to preconceived notions about AI.

Several factors may contribute to this finding in an academic context. Firstly, teachers may have limited knowledge regarding the pedagogical potential of AI applications. Secondly, the availability and accessibility of these technologies play a crucial role in effectively incorporating technology into the teaching process (Dalal et al., 2017). To address this issue, educators and educational administrators should actively pursue and allocate sufficient time, expertise, funds, and resources to ensure that teachers receive comprehensive in-service professional development on AI and its applications (Antonenko & Abramowitz, 2023; Celik, 2023; Park et al., 2023). Additionally, establishing learning communities can be considered an alternative approach (Dong et al., 2020). Workshops that provide teachers with ideas, tools, and lessons can offer a better understanding of what AI entails and how it can benefit students. These workshops can also provide practical ways for teachers to apply AI technologies in various contexts. It can be inferred that teachers who engage with AI tools demonstrate more positive attitudes and self-efficacy toward AI integration. Lodge et al. (2023) demonstrated that teachers can gain a deeper understanding of the pedagogical benefits offered by AI when they actively engage with AI-based tools. Therefore, it is crucial to emphasize the specific benefits and advantages associated with the integration of AI technology into educational practices during teacher training sessions and workshops (Ma & Lei, 2024).

In addition to teachers' professional knowledge, teacher motivation and attitude constitute another aspect of technology integration (Shin, 2022). Given the rapid advancement of technologies and the growing necessity of incorporating technology in instruction, teachers face stress in keeping up with emerging technologies and developing effective pedagogical strategies to make the most of such technologies. Every interaction a teacher has with popular media, such as television, radio, film, and social media, can influence their perception of AI in various ways (Antonenko & Abramowitz, 2023). Furthermore, the study discovered that teachers have a basic understanding of the potential risks and consequences associated with the use of AI, particularly about different social media platforms. Teachers may feel overwhelmed by the technical complexities of AI and may need more certainty regarding its effective integration into their teaching approaches (Huang, 2021 cited in Hopcan et al., 2023). Some educators may have concerns regarding the lack of transparency and

impartiality demonstrated by AI systems in their decision-making processes, which can lead to potential issues about fairness and equity (Nguyen et al., 2023).

Although it is crucial to work with in-service teachers to integrate AI tools into learning environments, it is also important to incorporate AI tools into teacher education programs. Preservice teachers have a significant role in influencing the implementation of AI technologies in educational settings (Zhang et al., 2023). They can acquire knowledge about AI technologies through core courses in the teacher education curriculum, such as learning theory and educational technology courses. Moreover, these courses can be designed specifically to promote ethical considerations among preservice teachers and enhance their understanding of the application of educational AI (Celik, 2023). These courses should also expand preservice teachers' knowledge of how AI technologies are applied to specific subjects. In preservice education, courses such as information technologies, instructional technologies, material design, and special teaching methods need to be revised to incorporate AI and the TPACK conceptual framework (Ersoy et al., 2016).

The research findings indicate that the participating teachers in this study demonstrated a high level of digital proficiency, having grown up with technology and being proficient in multitasking. They were also comfortable utilizing graphics for communication and preferred instant gratification and rewards. Furthermore, a significant finding of this research is the positive correlation ($r = .37$, $p < .01$) between digital proficiency and teachers' AI-TPACK competencies. Additionally, the study revealed varying degrees of relationship between the sub-dimensions of AI-TK, AI-TPK, AI-TCK, AI-TPACK, ethical considerations, and digital proficiency, ranging from 0.18 to 0.37.

This study was conducted to examine the relationship between digital proficiency and AI-TPACK competencies using a structural equation model. The findings of this study support the hypothesis that digital proficiency significantly predicts AI-TPACK competencies. Individuals with easy access to technology like computers, smartphones, and the internet tend to have more positive attitudes towards AI. This can be attributed to their familiarity and comfort with these technological advancements. On the other hand, individuals who lack convenient access to technology may display more significant skepticism or fear towards AI due to their limited exposure and understanding of its application and potential consequences. For example, older individuals may have less familiarity with AI technologies than younger generations, which can lead to higher anxiety or discomfort when interacting with AI systems. In conclusion, accessibility to technology plays a crucial role in shaping attitudes towards machine learning by influencing individuals' familiarity and comfort with technology, as well as providing opportunities for interaction and learning from AI (Hopcan et al., 2024).

Some studies investigate teachers' intention to use AI technologies in teaching. The results of a study conducted by Nja et al. (2023) also indicate that anticipated benefits, perceived ease of use, and attitudes toward utilizing AI significantly influence teachers' behavioral intentions to use AI. Similarly, a study by Zhang et al. (2023) discovered that perceived ease of use and usefulness emerged as the primary determinants influencing teachers' candidates' propensity to adopt AI. The findings of the research conducted by Ma and Lei (2024) have established that the primary

determinants of behavioral intention to adopt AI technologies are perceived usefulness and AI literacy. Celik (2023) argues that the promotion of AI will be more prevalent as teachers become more knowledgeable about field-specific tools based on this technology.

8.1 Limitations and future research

Several limitations should be considered in this study. Firstly, the data collection method used relied on self-report scales and online tools, which may impact the validity of the research findings. It is recommended that future research consider using hard copies for data collection in addition to online tools. In this study, data were collected from teachers using the EBA platform and AI-based tools. In future research, teachers can be informed about the applications of AI and data collection can be conducted after they have utilized these tools. Additionally, qualitative methods such as interviews and observations could be employed to conduct more in-depth research in future studies.

Secondly, a convenience sampling method was used in this study, and the data was not collected from all regions of Turkey. For future studies, it is suggested to use a stratified sampling method to ensure that data is collected from all regions in Turkey. Furthermore, it is essential to acknowledge that the sample size may have specific limitations. Although the sample size of the study was sufficient for testing the study hypotheses, it would be advantageous to gather data from a larger sample in future research.

Lastly, this study did not include the examination of the effects of demographic variables such as gender and department on AI-TPACK competencies within the model. The 401 samples were not categorized, particularly with regard to the impact of different age groups. It is crucial to acknowledge that age can be a significant variable that influences specific analytical findings. Future research could use advanced analysis techniques, such as Hierarchical Linear Modelling, to explore the relationships between these variables. In addition, future studies can investigate the variables that influence the AI-TPACK competencies of teacher candidates.

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Data availability The collected data used to support the findings of this study are available from the corresponding author upon request.

Declarations

Conflict of interest The author declares that they have no conflict of interest.

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