



Are Turkish pre-service teachers worried about AI? A study on AI anxiety and digital literacy

Damla Ayduğ¹ · Hakan Altınpulluk²

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Abstract

The primary objective of this study is to determine whether the level of digital literacy among pre-service teachers reliably correlates with their anxiety levels concerning artificial intelligence. The study was conducted as a correlational study, with a sample size of 221 pre-service teachers. The study's population comprised 3922 pre-service teachers enrolled at Turkish state and private universities. To collect study data, the researchers used the “Personal Information Form,” “Digital Literacy Scale,” and “Artificial Intelligence Anxiety Scale.” The data were analyzed using stepwise regression analysis and descriptive statistics. The study's results indicated that pre-service teachers exhibited high levels of digital literacy and moderate degrees of anxiety regarding artificial intelligence. Regression analysis revealed that 10.3% of pre-service teachers' anxiety concerning artificial intelligence could be predicted by the technical sub-dimension of digital literacy. Consequently, it was demonstrated that pre-service teachers' apprehensions regarding artificial intelligence decreased as their perception of technical digital fluency increased. Other sub-dimensions of digital literacy were deemed insignificant in predicting the anxiety levels of pre-service teachers regarding artificial intelligence. Based on these findings, suggestions for future study directions were proposed.

Keywords Artificial intelligence anxiety · Digital literacy · Pre-service teachers · Quantitative · Stepwise regression

1 Introduction

Education stands out as one of the fields most profoundly impacted by technological advancements. Artificial intelligence (AI), as one of the most exciting and rapidly evolving technologies of our era, is shaping education and fundamentally altering the learning–teaching processes. The integration of AI in education is bringing about revolutionary transformations and significant contributions, such as enhancing the experiences of students and teachers, personalizing learning processes, and boosting the efficiency of educational institutions (Aşık et al. 2023).

Advanced computer programs capable of mimicking human behavior and assisting individuals in various tasks

are commonly referred to as AI (Scott et al. 2021). AI offers a broad spectrum of educational opportunities, including automated grading, predictive analytics, adaptive learning, intelligent tutoring systems, and personalized learning. Although there is widespread recognition of the many advantages of AI in education, it is crucial to address teachers' and pre-service teachers' concerns about this technology to ensure its effective and fruitful implementation in educational settings, as noted by Hopcan et al. (2023).

To comprehensively assess the psychologic and emotional ramifications of AI technologies on individuals, a thorough examination of the mechanisms underlying general anxiety is imperative. Anxiety is basically seen as a negative emotion associated with worry, nervousness, fear, self-doubt and frustration (Williams et al. 2016). In 1847, Feuchtersleben first observed anxiety caused by physiologic diseases. Since the 1890s, the idea that anxiety is a separate mental state that can develop with many diseases has become widespread (Berrios 1996). During the anxiety process, the human body develops a number of physiologic and psychologic reactions. Palpitations, dry mouth, nervousness, muscle tension, pain, sweating and difficulty in breathing are

✉ Damla Ayduğ
damla.aydug@gedik.edu.tr

Hakan Altınpulluk
hakanaltinpulluk@anadolu.edu.tr

¹ Istanbul Gedik University, Istanbul, Turkey

² Anadolu University, Eskişehir, Turkey

some of these symptoms (Kafes 2021). According to this perspective, anxiety is defined as the emotional and psychological responses of individuals to uncertain situations and events in general. Conversely, the concept of artificial intelligence (AI) anxiety is more specific, emphasizing concerns regarding technological uncertainties and the potential for novel applications, including AI, to become uncontrolled in future. In this context, it has been observed that symptoms associated with classical anxiety also manifest in relation to emerging technologies, such as AI, and that the intensity of this anxiety tends to increase in circumstances where individuals do not perceive a sense of security.

The term “AI Anxiety” is used to describe feelings of fear and anxiety associated with AI that is perceived as uncontrollable (Johnson and Verdicchio 2017). Wang and Wang (2022) noted that AI anxiety studies arose from concerns that computers could threaten the essence of being “human,” defining AI anxiety as the emotional fear response that inhibits individuals from interacting with AI. Kaya et al. (2022) define AI anxiety as an excessive fear of the changes in personal or social life brought about by AI technologies. Green (2020) argues that AI raises concerns about job displacement, privacy and transparency challenges, algorithmic biases, increasing socio-economic disparities, and unethical behaviors. Among the concerns of pre-service teachers about AI technologies are fears of job loss (Civelek 2009), ethical dilemmas (Stahl 2021), and the need to acquire new skills (Wang and Wang 2022).

It is anticipated that fear related to AI will spread globally and have a significant impact on people’s future careers, education, and personal trajectories (Vicsek 2021; Vicsek et al. 2024). Furthermore, anxiety related to AI can lead to various other social issues. Despite the fact that academics have not given much thought to the idea of AI anxiety, it seems like a subject that warrants further investigation (Li and Huang 2020). In this sense, it is possible to argue that with the increasing use of AI technologies in the field of education, the emergence of anxiety among pre-service teachers about AI is natural and understandable. However, it can also be argued that this anxiety can be overcome by improving pre-service teachers’ digital skills, with digital literacy being one of these abilities.

A body of research has emerged on the subject of AI and AI anxiety among pre-service teachers (Aktulun et al. 2024; Ayduğ and Altinpulluk 2023; Eyüp and Kayhan 2023). In their study, Zhang et al. (2023) investigated the acceptance of artificial intelligence (AI) among pre-service teachers. They concluded that artificial intelligence anxiety, one of the variables examined, differed significantly according to gender. Falebita (2025) also found that there were significant differences in the gender variable in the research that assessed AI anxiety among pre-service teachers in university teacher education programs. She therefore emphasized

that AI literacy studies should be placed on the agenda as a matter of urgency. Here, the concept of “Artificial Misinformation” should be underlined (Shin 2024). Based on the fact that concerns about artificial intelligence are mostly based on online misinformation generation and sharing, it can be stated that human – AI interaction, the creation of AI systems with reliable and ethical algorithms, and artificial intelligence literacy, which is a sub-branch of digital literacy, should be expanded.

While literacy traditionally referred to the ability to extract words and meanings from written text (Kartal 2007), today it encompasses not only making sense of written words but also having knowledge in specific fields (Som and Kurt 2012). The term “digital” pertains to the process of transferring and utilizing information in online or offline environments (Dinlemez 2021). Consequently, digital literacy can be defined as the ability to make sense of information in both online and offline environments. Ata and Yıldırım (2019) define it as the acquisition of relevant knowledge for a specific objective in real and virtual scenarios, and effectively implementing it through appropriate techniques. Ribble (2015) considers digital literacy as a component of digital citizenship that encompasses competencies such as being familiar with diverse technologies, using them correctly, accessing precise information in the digital realm, understanding information production and sharing, and integrating technology into the teaching–learning process. Hull et al. (2003) describe digital literacy as the capacity to comprehend, evaluate, and communicate information conveyed through diverse digital or electronic formats, highlighting that the skills, tasks, and mastery level of technologies required for digital literacy continue to evolve. Thus, digital literacy is perceived as a broader concept than merely knowing how to operate devices like computers and tablets, being proficient with their software, or being an effective user (Karabacak and Sezgin 2019).

Digital literacy encompasses an individual’s understanding, mindset, and proficiency in effectively utilizing digital tools for tasks such as accessing, evaluating, and creating digital content, communicating with others, and fostering positive social engagement across various life scenarios (Martin 2005). Payton and Hague (2010) argue that digital literacy comprises several sub-dimensions, including creativity, collaborative development, digital security, effective communication, information search and selection, critical thinking and evaluation, functional skills, and comprehension of cultural and social phenomena. Ata and Yıldırım (2019) enumerate competencies within digital literacy, covering skills such as utilization, interpretation, sharing, collaboration, and critical evaluation of digital media, as well as proficiency in creating digital content and upholding social responsibilities and ethical

standards. Eshet-Alkalai (2004) suggests that digital literacy encompasses various literacies, including photo-visual literacy, reproduction literacy, branching literacy, information literacy, and socio-emotional literacy. Despite the diverse definitions, there is a shared recognition that digital literacy is a vital skill for contemporary students navigating the technological, cognitive, and socio-emotional demands of the digital era (List et al. 2020). In addition, digital literacy is highlighted as a key component among 21st-century skills (Trilling and Fadel 2009). Dabner (2015) underscores the importance of providing conducive conditions for acquiring digital literacy skills, emphasizing the need to investigate and examine what it entails to interact with digital resources. Given that teachers are expected to possess digital literacy skills and impart them to their students through formal and informal methods, it can be argued that digital literacy skills have become increasingly crucial for teachers compared to other professional groups (Gülay-Ogelman et al. 2022). Similarly, Özerbaş and Kuralbayeva (2018) emphasized that teachers should possess this competence to effectively teach individuals how and why to utilize technology within education. Assessing the digital literacy levels of teachers, pre-service teachers, and students is crucial for shaping necessary teacher education programs and empowering teachers to offer technological guidance to their students (Üstündağ et al. 2017).

The concept of digital literacy is essential for students to understand the capabilities of computer and internet technologies and to teach them how to effectively utilize the acquired information. For students to effectively navigate computer-assisted education provided in educational settings and derive maximum benefit from it, pre-service teachers must first possess digital literacy skills (Dinlemez 2021).

A considerable body of research exists in the academic literature on digital literacies of pre-service teachers (Çetin 2021; List 2019; List et al. 2020). Ciampa and Gallagher (2020) examined the self-efficacy beliefs of pre-service teachers in Canada and the USA about digital literacy. Their findings revealed that pre-service teachers exhibited high levels of self-efficacy in twenty-first century skills and diversity. However, they also exhibited lower levels of self-efficacy in early literacy skills (Ciampa and Gallagher 2020). Falloon (2020) analyzed existing models for the development of digital competencies in pre-service teacher education and proposed a more comprehensive framework that goes beyond technical skills and includes issues such as productivity, safety and ethics. In a similar vein, an investigation by Chun et al. 2021 examined the relationship between teachers' digital literacy levels and their teaching expertise. This study found that teachers with high digital literacy levels tend to adopt more effective teaching strategies.

In conclusion, as the significance of AI technologies in education continues to grow, comprehending the concerns of pre-service teachers regarding these technologies and supporting them through this new digital transformation process will contribute to a more promising future for the education system. Digital literacy skills can serve as a compass and assurance for pre-service teachers in this journey, equipping them to thrive in future digital education landscape. It is believed that digital literacy skills can assist pre-service teachers in managing their apprehensions about AI technologies, helping them to play a successful role in the digitalized educational environment of tomorrow. Despite an absence of research directly examining AI anxiety and digital literacy among pre-service teachers, there is a body of literature exploring analogous issues. Abuadas and Albikawi (2025) investigated the prediction of nursing students' behavioral intention to use AI, and also examined the variable of digital literacy and anxiety. The analysis of the data collected from 460 students indicated that digital literacy emerged as a significant predictor of behavioral intention to use AI. Conversely, anxiety was found to act as a hindering factor. In their 2024 study, Schiavo, Businaro and Zancanaro examined the effect of literacy and anxiety on the acceptance of AI. The researchers emphasized that anxiety acts as a complementary partial mediator between AI literacy and AI acceptance. This conclusion was based on data collected from 313 participants. The authors further posit that anxiety exerts a minimal yet substantial direct negative influence, while concurrently functioning as a pivotal mediator in the relationship between literacy and its consequences. In particular, the learning and sociotechnical dimensions of AI anxiety act as a complementary partial mediator between AI literacy and acceptance, meaning that part of the effect of literacy on acceptance is mediated through AI anxiety. Pan et al. (2025) study identified that AI literacy and AI anxiety are significant variables in influencing Chinese academics' perceived ease of use, perceived usefulness and behavioral intentions in reading AI-supported literature.

This study aims to contribute to the effectiveness of pre-service teachers in utilizing AI technologies in their future teaching roles and to alleviate their anxiety about technology by enhancing their digital literacy levels. It is plausible that pre-service teachers who comprehend the role of AI in education and the significance of digital literacy will be better equipped for the future education system and capable of leveraging technology's opportunities optimally. Given these considerations, this study seeks to explore the relationship between AI anxiety and digital literacy levels from the perspectives of pre-service teachers. To address this primary objective, the following research questions will be examined:

1. How anxious are pre-service teachers about AI?
2. What is the level of digital literacy among pre-service teachers?
3. Do pre-service teachers' digital literacy levels significantly predict their AI anxiety?

2 Methodology

The study employed the survey model, one of the quantitative research approaches. Survey models are utilized to investigate whether two or more variables are changing simultaneously, and if so, to what extent and in which direction (Creswell 2014). Within the framework of this research, the aim is to determine whether the digital literacy levels of pre-service teachers influence the level of AI anxiety, and if so, to ascertain the direction of this influence using the survey model.

2.1 Participants

A total of 3922 pre-service teachers enrolled in spring semester 2021–2022 courses at foundational and state universities make up the study's population. The sample consists of 221 pre-service teachers and was created using a basic random sampling procedure. Since the study aims to draw a general picture about pre-service teachers' AI anxiety levels, the use of AI was not taken under control. Table 1 displays the pre-service teachers in the sample's demographic data.

Upon frequencies of Table 1, it reveals that 146 (66.06%) of the pre-service teachers are female, while 75 (33.94%) are male. Regarding age distribution among pre-service

teachers, 14 (6.34%) were aged 17–18, 88 (39.82%) were aged 19–20, 86 (38.91%) were aged 21–22, 21 (9.5%) were aged 23–24, and 12 (5.43%) were aged 25 and over. Furthermore, 194 (87.78%) of the pre-service teachers were enrolled at a state university, while 27 (12.22%) were enrolled at a foundation university. This situation is attributable to the presence of a significant number of pre-service teachers at a public university, largely attributable to the establishment of a faculty of education. Conversely, a private university possesses only a single teaching department, and measures have been taken to ensure proportional representation of the sample.

2.2 Data collection instruments

Artificial Intelligence Anxiety Scale: The scale developed by Wang and Wang (2022) and adapted into Turkish by Terzi (2020) was used. The scale was first published online in 2019, and the full text was published in the journal with volume and issue number in 2022. The scale consists of 4 sub-dimensions and 21 items: learning, job replacement, sociotechnical blindness and AI configuration. Within the scope of the validity study of the 7-point Likert-type scale, Terzi (2020) conducted a factor analysis with the data obtained from 301 students and found that the scale consisted of 4 factors. To validate the four-factor structure derived from exploratory factor analysis (EFA), confirmatory factor analysis (CFA) was conducted using data from 222 students. The results of the CFA indicated satisfactory fit indices: $\chi^2/df = 2.57$, TLI = 0.93, CFI = 0.94, and SRMR = 0.069, confirming the factor structure of the scale. Moreover, the scale's structure was corroborated through second-level CFA, yielding favorable fit indices ($\chi^2 = 286.60$, Sd = 115, $p = 0.00$; RMSEA = 0.074, GFI = 0.96, AGFI = 0.92, CFI = 0.97, NFI = 0.96, NNFI = 0.97, SRMR = 0.048). Internal consistency coefficients, computed using data from 222 students, demonstrated high reliability for the entire scale ($\alpha = 0.96$) and its sub-dimensions: learning ($\alpha = 0.89$), job replacement ($\alpha = 0.95$), sociotechnical blindness ($\alpha = 0.89$), and AI configuration ($\alpha = 0.95$) (Terzi 2020).

For this study, the reliability and validity values of the AI Anxiety Scale were recalculated. The fit indices [$(\chi^2/sd) = 2.369$, RMSEA = 0.079, CFI = 0.942, TLI = 0.929, SRMR = 0.078] obtained as a result of CFA to determine the validity of the scale showed that the four-dimensional structure of the scale was valid. The total scale's internal consistency reliability (α) was determined to be .94, while the sub-dimensions for learning, job replacement, sociotechnical blindness, and AI configuration had α values of .88, .92, .89, and .92, respectively. **Digital Literacy Scale:** In this study, the scale developed by Ng (2012) and adapted into Turkish by Hamutoğlu et al. (2017) was used to measure the participants' digital literacy levels. The scale consists of

Table 1 Demographic information of the pre-service teachers in the sample

Variables		F	%
Gender	Female	146	66.06
	Male	75	33.94
Age	17–18	14	6.34
	19–20	88	39.82
	21–22	86	38.91
	23–24	21	9.50
	25 and above	12	5.43
University type	State	194	87.78
	Foundation	27	12.22
Class level	1	42	19.00
	2	84	38.01
	3	83	37.56
	4	12	5.43
Total	221	100.0	

4 sub-dimensions (attitude, technical, cognitive and social) and 17 items. Within the scope of the validity study of the scale, factor analysis was performed by Hamutoğlu et al. (2017) with the data obtained from 185 students and it was determined that the scale consisted of four factors. The total variance explained by these four factors is 65.78%. The 7-item attitude dimension explains 10.52% of the variance, the 6-item technical dimension explains 44.04%, the 2-item cognitive dimension explains 6.00% and the 2-item social dimension explains 5.22%. To confirm the four-factor structure of the scale obtained as a result of EFA, CFA was also performed on a data set obtained from 210 students. As a result of CFA, $\chi^2 = 268.45$, $sd = 113$ ($p = 0.00$), $RMSEA = 0.071$, $GFI = 0.93$, $AGFI = 0.91$, $CFI = 0.98$, $NFI = 0.96$, $NNFI = 0.97$ and $SRMR = 0.05$ were found and it was determined that the factor structure of the scale was confirmed. In addition, the validity of the scale's structure was confirmed through second-level CFA ($\chi^2 = 286.60$, $df = 115$, $p = 0.00$), with satisfactory fit indices ($RMSEA = 0.074$, $GFI = 0.96$, $AGFI = 0.92$, $CFI = 0.97$, $NFI = 0.96$, $NNFI = 0.97$, and $SRMR = 0.048$). Internal consistency coefficients were computed based on data from 185 students, revealing high reliability for the overall scale ($\alpha = 0.93$) and its sub-dimensions: attitude ($\alpha = 0.88$), technical ($\alpha = 0.89$), cognitive ($\alpha = 0.70$), and social ($\alpha = 0.72$). Furthermore, test–retest reliability coefficients were calculated, yielding high values for the entire scale ($r = 0.98$) and its sub-dimensions: attitude ($r = 0.89$), technical ($r = 0.90$), cognitive ($r = 0.87$), and social ($r = 0.79$) (Hamutoğlu et al. 2017). For this study, the Digital Literacy Scale's reliability and validity metrics were reassessed. CFA yielded favorable fit indices [$(\chi^2/sd) = 2.015$, $RMSEA = 0.073$, $CFI = 0.958$, $TLI = 0.948$, $SRMR = 0.051$], confirming the scale's four-dimensional structure as valid. The internal consistency reliability (α) was determined as 0.95 for the overall scale, 0.93 for the attitude and technical sub-dimensions, and 0.71 for the cognitive and 0.75 for the social sub-dimensions.

Personal Information Form: This form was prepared by the researchers to obtain demographic data of the participants and included questions about the characteristics of the pre-service teachers such as age, gender, grade level, and the university they attended.

2.3 Data collection process and analysis

Before analyzing the data collected within the scope of the research, assumptions were tested to determine whether the data were suitable for the analysis techniques to be used. For this purpose, missing data and outliers were examined. Since the data collection tools were collected through Google forms, no incomplete measurement tool was found. Furthermore, scatter plots, skewness, and kurtosis coefficients

Table 2 Skewness and kurtosis coefficients for the research data

Dimension	Skewness	Df	Kurtosis	df
Learning	0.767	0.164	0.142	0.326
Job replacement	0.001	0.164	-0.914	0.326
Sociotechnical blindness	-0.100	0.164	-0.950	0.326
AI configuration	0.199	0.164	-1.133	0.326
AI anxiety	-0.011	0.164	-0.636	0.326
Attitude	-0.794	0.164	-0.004	0.326
Technical	-0.203	0.164	-0.624	0.326
Cognitive	-0.336	0.164	-0.432	0.326
Social	-0.411	0.164	-0.403	0.326
Digital literacy	-0.406	0.164	-0.297	0.326

were analyzed to assess the data's eligibility for analysis and ascertain their normal distribution. It was determined that the assumption of a normal distribution was satisfied because the skewness and kurtosis coefficients varied between -1.5 and +1.5 (Tabachnick and Fidell 2015), and parametric tests were employed in the analysis. Table 2 displays the skewness and kurtosis coefficients for the data.

Descriptive statistics (arithmetic mean, min and max score, standard deviation) were used in the analyses conducted to answer the first two sub-questions of the study. Stepwise regression analysis was conducted to determine the last sub-objective of the study, which was predictive. However, before proceeding with this analysis, the assumptions of multiple regression analysis were examined. The analysis was conducted with the data obtained from 221 participants. The correlation coefficients between the variables were calculated to determine whether the singularity, another assumption of multiple regression analysis, was violated, and since the values obtained were found to be below 0.70, it was concluded that the assumption of singularity was met (Pallant 2020). Next, to ascertain whether there was an issue with multicollinearity among the predictor variables, tolerance and VIF values were investigated. According to Field (2009), it is advised that the VIF value be fewer than 10 and the tolerance value be more than 0.02. The VIF value was 1.00 and the tolerance value was 1.00, based on the regression model that was developed during the course of this study. It is determined that there is not a multicollinearity issue in this situation. To establish whether auto-correlation exists between the variables, the Durbin–Watson value was finally investigated. It was found that 1.33 was the recommended value, which should fall between 1 and 3 (Field 2009).

3 Ethical statement

To confirm that the study was ethically feasible, the Ethics Committee of Istanbul Gedik University was consulted. As a result of the examination, it was concluded that the research was ethically feasible and the ethics committee report numbered E-71457743–050.01.04–2022.137548.29 was obtained.

4 Findings

In line with the first two sub-objectives of the study, descriptive statistics were calculated to obtain findings on pre-service teachers’ AI anxiety and digital literacy levels. Table 3 displays the results of descriptive statistics.

It was concluded from the analyses carried out to produce results for the study’s first sub-objective that pre-service teachers’ perceptions of their degree of AI anxiety were “Medium” ($\bar{x}=3.28$, $sd=1.21$). The pre-service teachers’

views on the sub-dimensions of job replacement ($\bar{x}=3.94$, $sd=1.66$), sociotechnical blindness ($\bar{x}=4.08$, $sd=0.25$), and AI configuration ($\bar{x}=3.67$, $sd=1.91$) were likewise at medium levels when the AI anxiety levels were examined in relation to the sub-dimensions of the scale. In contrast, their views on the learning ($\bar{x}=2.23$, $sd=1.04$) sub-dimension were at a low level.

The studies carried out to gather information for the study’s second sub-objective revealed that pre-service teachers’ perceptions of digital literacy levels were at a “High” level ($\bar{x}=3.69$, $sd=0.85$). The pre-service teachers’ perceptions of the attitude ($\bar{x}=3.92$, $sd=0.94$), technical ($\bar{x}=3.52$, $sd=0.97$), cognitive ($\bar{x}=3.54$, $sd=0.99$), and social ($\bar{x}=3.53$, $sd=1.05$) sub-dimensions of the scale were similarly found to be high when the digital literacy levels were analyzed in terms of these sub-dimensions.

The last sub-objective of the research is to determine whether pre-service teachers’ digital literacy levels are a significant predictor of their AI anxiety levels. Before proceeding to the stepwise regression analysis for this purpose, correlation analysis was conducted to determine the relationships between variables. The results of the correlation analysis showing the relationships between the variables are presented in Table 4.

Following correlation analysis, it was observed that there were statistically significant, albeit low-level, negative correlations between overall AI anxiety and total digital literacy scores (-0.288). Further examination of the relationship between AI anxiety and digital literacy sub-dimensions revealed similar negative correlations, albeit at varying levels: attitude (-0.201), technical (-0.321), cognitive (-0.288), and social (-0.182). Subsequently, stepwise regression analysis was conducted to explore these relationships further, with the results presented in Table 5.

When the results of the stepwise regression analysis in Table 5 are analyzed, it is seen that only the technical sub-dimension is included in the model. Accordingly, the

Table 3 Descriptive statistics values for pre-service teachers’ views on research variables

Dimension	n	\bar{X}	Sd	Min	Max
Learning	221	2.23	1.04	1.00	6.00
Job replacement	221	3.94	1.66	1.00	7.00
Sociotechnical blindness	221	4.08	0.25	1.00	7.00
AI configuration	221	3.67	1.91	1.00	7.00
AI anxiety	221	3.28	1.21	1.00	5.86
Attitude	221	3.92	0.94	1.00	5.00
Technical	221	3.52	0.97	1.00	5.00
Cognitive	221	3.54	0.99	1.00	5.00
Social	221	3.53	1.05	1.00	5.00
Digital literacy	221	3.69	0.85	1.00	5.00

Table 4 Correlation coefficients between AI anxiety and digital literacy variables

Variables	1	2	3	4	5	6	7	8	9	10
Learning	1									
Job replacement	0.438**	1								
Sociotechnical blindness	0.374**	0.785**	1							
AI configuration	0.478**	0.691**	0.790**	1						
AI anxiety	0.702**	0.895**	0.870**	0.858**	1					
Attitude	-0.352**	-0.128	-0.019	-0.141*	-0.201**	1				
Technical	-0.397**	-0.276**	-0.132*	-0.219**	-0.321**	0.674**	1			
Cognitive	-0.352**	-0.259**	-0.133*	-0.167*	-0.288**	0.666**	0.792**	1		
Social	-0.234**	-0.144*	-0.072	-0.136*	-0.182**	0.586**	0.548**	0.583**	1	
Digital literacy	-0.404**	-0.227**	-0.091	-0.196**	-0.288**	0.907**	0.901**	0.847**	0.716**	1

** $p < 0.01$

Table 5 Stepwise regression analysis results

Model	Variable	<i>B</i>	SH _B	β	T	p	R ²	ΔR^2	F	p
1st Model	Technical	-1.410	0.281	-0.321	-5.02	0.000	0.103	0.099	25.22	0.000

*Dependent variable: AI anxiety

technical sub-dimension of digital literacy explains approximately 10.3% ($R^2 = 0.103$) of pre-service teachers' AI anxiety levels. Furthermore, it is also seen that the predictive power of the technical sub-dimension on AI anxiety is negative. According to this result, as pre-service teachers' technical digital literacy levels increase, their AI anxiety decreases. It was determined that other sub-dimensions of digital literacy did not have any contribution in terms of predicting pre-service teachers' AI anxiety levels.

4.1 Conclusion, discussion and recommendations

The analysis conducted for the first sub-objective of the study revealed that pre-service teachers' perceptions of AI anxiety were categorized as "Medium." While there is a lack of literature specifically addressing AI anxiety among pre-service teachers, studies involving various stakeholders in the education sector provide some insights. For instance, a phenomenological study conducted with pre-service teachers in Turkey explored their perspectives on AI. Data collected from 94 participants uncovered diverse interpretations of AI, accompanied by negative sentiments and a reluctance to envision a society governed by AI (Haseski 2019).

Although AI anxiety levels are generally found to be at a medium level in studies conducted with participants other than pre-service teachers, there is a study that reveals that they are at a low level. Similar to this study, Takıl et al. (2022) found that university students' AI anxiety scores were at a medium level. Özbek-Güven et al. (2023), on the other hand, found that students' anxiety levels about AI were at a moderate level in their study conducted with medical faculty students. In studies conducted with K-12 teachers instead of pre-service teachers, teachers' anxiety levels about AI were found to be moderate (Sevimli-Deniz 2022; Terzi 2020). The findings obtained in these studies and the findings obtained in the current study confirm each other. Gültekin et al. (2022) concluded that the AI anxiety of university students was low.

Although AI technologies have gained momentum in recent years, they have not yet reached their peak. In fact, countries do not yet know what kind of measures they should take regarding AI and the risks it will bring. One of the recent developments in this regard is that on December 09, 2023, the European Union (EU) Commission, the European Parliament and member states agreed on the world's first "Artificial Intelligence Act" (European Parliament 2024). Since it is not yet known what the risks of AI technologies,

which continue to develop, will be, it seems reasonable that pre-service teachers' anxiety is at a moderate level.

When the AI anxiety levels were examined in terms of the sub-dimensions of the scale, it was determined that the pre-service teachers' views on the sub-dimensions of job replacement, sociotechnical blindness and AI configuration were at medium levels, while their views on the learning sub-dimension were at a low level. The sociotechnical blindness dimension refers to the possibility of losing control of AI; the AI configuration dimension refers to the tendency to find the combination of human-like features with robotic features disturbing; and the job replacement dimension refers to the need for adaptation and job change with the change of business practices and the emergence of new business areas (Wang and Wang 2022).

According to the results of the study, pre-service teachers' anxiety about AI manifested itself with low scores in the learning sub-dimension. The learning sub-dimension expresses concerns about having to learn new things (Wang and Wang 2022). Similarly, Terzi's (2020) study revealed that teachers' concerns about learning techniques/products related to AI were lower than other sub-dimensions. This result shows that pre-service teachers are not concerned about issues related to learning AI and that learning activities related to these issues are in line with their professional expectations. One of the striking results here is that the job replacement dimension is at medium levels. The job replacement dimension is a dimension related to concerns such as increasing unemployment and decreasing employment, which is one of the main concerns about AI. In this regard, the study conducted by Wang et al. (2024) on university students in Taiwan demonstrates that AI job replacement anxiety exerts a positive effect on extrinsic motivation. Conversely, negative social influences, such as job loss anxiety due to AI, have the potential to impede students' acceptance of these technologies and their inclination to integrate them into their applications (Cho 2024). It is possible to state that the problem of technological developments creating employment loss (Schwab 2018), which dates back to Keynes' (1937) technological unemployment theory, is not considered as a very worrying situation by pre-service teachers. Similarly, in Howarth's (2024) study examining the projected rates of employment loss due to AI in the United Kingdom until 2030, it is seen that the loss in the field of education is projected as 8.5% and this projection is quite low compared to other sectors. This seems to support this finding of the study. In addition,

AI itself produces an output similar to this finding. When the AI is asked, “Will AI destroy the teaching profession?”, it gives the following answer:

“AI can transform and support the teaching profession, rather than destroy it altogether. AI-based educational technologies can assist teachers in providing education to students in a customized and effective way. However, AI does not completely eliminate the role of teachers. The role of teachers in areas such as human interaction, emotional connection, motivation and providing students with life skills is unique and cannot be completely replaced by AI. AI can be used as a tool to ease the workload of teachers and help students more effectively, but the importance and value of teachers is still immense (ChatGPT 2024).”

To summarize, the reasons why pre-service teachers’ anxiety levels are at a moderate level may be due to their inability to keep up with the rapid changes in this field, fear of losing their jobs, academic ethical problems, privacy and security problems. AI anxiety is generally fed by uncertainty and insecurity about technology. It can be stated that this trust problem stems from the lack of knowledge about AI. Digital literacy is the other variable examined in this study as one of the most important factors in eliminating this lack of knowledge.

In the study, some results were also obtained regarding digital literacy levels. According to the findings, the digital literacy levels of pre-service teachers are high. There are qualitative (Akayoğlu et al. 2020; Burnett 2011) and quantitative (Peled 2021; Tomczyk 2020) studies on examining the digital literacy levels of pre-service teachers.

Similar to the current study, research conducted with pre-service teachers has consistently shown high levels of digital literacy (Ata and Yıldırım 2019; Can et al. 2020; Dinlemez 2021). Ata and Yıldırım (2019) found high digital literacy levels among 295 pre-service teachers across various disciplines. Dinlemez (2021) similarly reported high levels of digital literacy among pre-service teachers. Karakuş and Ocak (2019) also found high levels of digital literacy self-efficacy among pre-service teachers. Thus, it can be inferred that the findings of this study align with those of previous research conducted in Turkey. One of the reasons for this situation may be that in the teacher education programs renewed by YÖK in 2018, there are compulsory courses such as information and instructional technologies and elective courses such as media literacy.

Upon analyzing the digital literacy levels in terms of the sub-dimensions of the scale, it was evident that pre-service teachers’ views on attitude, technical prowess, cognitive understanding, and social engagement were notably high. This is a positive development concerning the effective utilization of digital technologies within the educational

realm. It is foreseeable that these pre-service teachers will adeptly employ their digital skills in their classrooms once they transition into teaching roles. Moreover, the elevated proficiency across not only the technical dimension but also attitudinal, cognitive, and social aspects indicates that pre-service teachers can potentially enhance their students’ learning experiences to an even greater extent, thanks to these innovative attributes.

Another significant outcome of the study is that 10.3% of pre-service teachers’ AI anxiety is attributed to the technical sub-dimension of digital literacy. Accordingly, the technical sub-dimension negatively influences AI anxiety, implying that as pre-service teachers’ technical digital literacy levels increase, their AI anxiety decreases. Conversely, it was observed that the other sub-dimensions of digital literacy did not significantly contribute to predicting pre-service teachers’ levels of AI anxiety. The absence of prior studies exploring the relationship and predictive capacity of these two variables underscores the originality of this study and the pioneering nature of its findings.

In light of these findings, it can be inferred that possessing technical knowledge can mitigate concerns stemming from a lack of understanding about AI or other technological advancements. The high level of technical digital literacy among pre-service teachers may have fostered a sense of confidence and awareness regarding AI. Insufficient knowledge about technological matters like AI often leads to anxiety and apprehension, but as technical knowledge increases, individuals may experience reduced anxiety concerning AI or other technological innovations. Thus, these findings suggest that enhancing pre-service teachers’ technical knowledge levels is instrumental in alleviating their anxiety about AI.

The findings of this study indicated that the technical dimension of digital literacy emerged as the sole significant factor in mitigating AI anxiety. The study concluded that the attitudes, cognitive and social dimensions did not exert a substantial influence on this phenomenon. The finding that technical knowledge is a significant predictor of reduced anxiety toward artificial intelligence can be interpreted as suggesting that the acquisition of concrete knowledge and skills related to technology by pre-service teachers can lead to an increase in their sense of confidence. Conversely, the absence of statistical significance in the attitude, cognitive and social dimensions suggests that the general awareness and social interaction acquired in these areas are inadequate in reducing anxiety about technology. The absence of statistical significance in the prediction of AI anxiety by cognitive and social digital literacy in the study suggests that, in the context of pre-service teachers, their comprehension of AI in terms of conceptual or social interaction is less determinative than their technical skills. This finding suggests that pre-service teachers’ concerns

about AI stem more from a lack of confidence in the practical application of AI. The cognitive dimension has been found not to be a significant predictor, which may be indicative of the fact that theoretical knowledge does not eliminate pre-service teachers' uncertainties about artificial intelligence, and therefore does not alleviate their anxiety. In a similar vein, the social dimension's insignificance as a predictor can be interpreted as indicating that pre-service teachers' proficiency in utilising digital environments socially effectively does not translate into a reduction in their anxiety about artificial intelligence. The finding that the technical dimension of pre-service teachers' digital literacy has a negative effect on their anxiety levels regarding artificial intelligence is consistent with the results of the study conducted by Falebita (2025) with 1067 pre-service teachers. In their study, it was asserted that "AI literacy should be introduced with urgency to improve the ethical use of AI technologies and reduce AI anxiety among pre-service teachers". Consistent findings were attained in the study conducted by Ayanwale et al. (2024) on AI literacy with 529 pre-service teachers in Nigeria.

The study entails several limitations. First, the sample solely consists of pre-service teachers, thus limiting the generalizability of the findings. To enhance the study's scope, the inclusion of teachers or postgraduate researchers within the educational domain could provide a better understanding. Exploring diverse participant groups through different experimental designs would facilitate comparative analyses. Second, the sample size of 221 participants may restrict the reliability of the results. Conducting the study with a larger sample size could yield more nuanced insights. Furthermore, the uneven representation of pre-service teachers from state universities may introduce bias. A more balanced distribution across demographic variables would enhance the study's validity. Lastly, the reliance on self-report measures poses a limitation as it assumes the accuracy of responses, potentially leading to biased findings. This can be stated as a limitation since it requires that the answers given to the scales be accepted as correct even if they are not correct.

Drawing from these results, several suggestions can be proposed. Studies have indicated that the utilization of AI tools diminishes average AI anxiety (Sevimli-Deniz 2022). Consequently, it is advisable to organize activities aimed at encouraging pre-service teachers to incorporate AI tools within the framework of teacher education programs. Furthermore, the findings imply that digital literacy training or similar courses could serve as effective tools in reducing pre-service teachers' negative perceptions of AI technology.

The findings of this study indicate that the anxiety levels of pre-service teachers with regard to artificial intelligence are, on the whole, moderate. The finding that pre-service teachers with high levels of technical digital

literacy experience significantly lower levels of AI anxiety suggests that digital literacy training should be integrated into teacher training programs, with a focus on technical skills. It is therefore recommended that technical courses be incorporated into teacher training programs, utilizing practical applications of artificial intelligence tools. Furthermore, the low level of anxiety in the learning dimension indicates that if the learning needs of pre-service teachers in relation to artificial intelligence are met, their anxiety will decrease and they will be more receptive to the subject. Consequently, the provision of support to pre-service teachers in the domain of artificial intelligence education has the potential to mitigate their uncertainty and anxiety regarding this field. In this context, the organization of practical workshops and activities, which would allow pre-service teachers to interact directly with artificial intelligence tools, is recommended. Furthermore, the moderate level of job replacement anxiety highlights the necessity for training to facilitate the adaptation of pre-service teachers to labor force changes. The concerns of pre-service teachers in the job replacement dimension may be attributable to the uncertainties surrounding the labor force changes that artificial intelligence will engender in future. In light of these concerns, it is recommended that teacher education programs incorporate modules addressing the impact of artificial intelligence on the labor market, with a view to enhancing pre-service teachers' career adaptation skills. Finally, in future studies, it is suggested to examine the effects of cognitive and social dimensions of digital literacy on AI anxiety in different cultural and educational contexts.

Digital literacy training, courses incorporating technological tools, and analogous initiatives can assist pre-service teachers in utilizing AI technology more effectively and securely, thus reducing their anxiety in this domain and fostering a more positive outlook toward technology in general. However, the findings also highlight that digital literacy levels alone are insufficient to mitigate concerns regarding AI usage. Thus, it is recommended to provide additional training and guidance to pre-service teachers on the pedagogical applications of AI technology. Moreover, raising awareness about the ethical, privacy, security, and societal ramifications of AI could prove beneficial. By undertaking such initiatives, pre-service teachers' anxieties regarding AI technology may diminish, encouraging them to seamlessly integrate this technology into their future educational endeavors.

In conclusion, this study underscores the significance of digital literacy levels as a crucial predictor for comprehending and alleviating pre-service teachers' anxiety towards AI usage. Nevertheless, further research in this domain is warranted, and diverse training, orientation, and guidance strategies need to be developed accordingly.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare no competing interests.

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