Assessing structural relationships in pre-service preschool teachers' perceived AI readiness: Do emotional and psychological aspects matter?

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Preschool pre-service teachers need to be prepared for the age of artificial intelligence (AI) as part of the teaching force; however, much research is still needed in this area. This study aimed to explore the structural relationships in pre-service preschool teachers' perceived AI readiness, focusing on AI literacy, AI anxiety, AI confidence and AI relevance. The study involved 194 participants from seven universities in Taiwan. Data were analysed using SmartPLS software through partial least squares structural equation modelling. The results confirmed that the constructed model was a good fit for the data, with the adapted questionnaire showing adequate reliability and convergent validity. Key findings highlight the crucial mediating roles of preschool teachers' AI confidence and AI relevance in connecting their AI literacy to their AI readiness. This suggests that a cognitive understanding of AI does not directly translate into a readiness to use AI without including emotional engagement and perceived usefulness. Moreover, the study identified AI anxiety as a significant negative predictor of AI readiness among preschool teachers. This study uniquely contributes by clarifying how emotional and cognitive dimensions interact structurally, thus guiding targeted interventions in teacher preparation.

Implications for practice or policy:

- Teacher training programmes should enhance AI literacy and build AI confidence.
- Educators need to address AI anxiety to improve readiness.
- AI relevance must be demonstrated for practical classroom applications.
- Early childhood educators should integrate emotional engagement with AI teaching.
- Policymakers should support AI readiness initiatives in teacher education.

Keywords: artificial intelligence (AI), AI anxiety, AI readiness, early childhood education, preschool

Introduction

Artificial intelligence in early childhood education

The prevalence of artificial intelligence (AI) is fundamentally altering the traditional approaches to teaching and learning. The call to prepare school students to learn about these emerging technologies has garnered significant attention over the past few years (Chiu & Chai, 2020). If used properly, AI can assess and predict teachers' and students' performances, offering continuous feedback (Rad et al., 2024; Zheng et al., 2024). This approach not only improves digital literacy but also enhances teaching and learning processes (Ali, 2022; Niu et al., 2022; S. Wang et al., 2023). Through a qualitative approach to investigating children's play with AI robotic toys, Kewalramani et al. (2021) found that playing with AI robots can enhance children's creative, emotional and collaborative inquiry. Additionally, meta-analyses investigating the effectiveness of AI in education have identified positive impacts of AI on learning achievement and learning perceptions (Alemdag, 2025; Wu & Yu, 2024; Zheng et al., 2021).

Most studies on AI education have primarily concentrated on the elementary, secondary, and tertiary education levels, with scant focus on AI concepts in the early childhood education context (Su et al., 2023; Su & Yang, 2024; Yang, 2022). This might be due to the widespread belief that AI, viewed as a complex subject, is beyond young children's comprehension. Since the implementation of AI is all around us and has become a part of human life, many researchers have supported the development of young children's AI understanding (Lim, 2023; Su & Yang, 2024). Yang proposed three reasons for learning AI in the early years: First, understanding and using the basic functions of AI has become an essential aspect of digital literacy in a technologically evolving society. Second, it is essential to enable children to comprehend, utilise and assess AI through guided learning, enhancing their interdisciplinary education. Third, children can understand the essential functions of AI, especially when provided with age-appropriate scaffolding and AI toys. Thus, preschool teachers play a vital role in shaping the future digital literacy and AI competence of the next generation. Their emotional and psychological responses (e.g., literacy, anxiety, confidence and relevance) to AI can significantly impact young learners (Su & Yang, 2024).

Compared to previous early childhood studies, this research fills an important gap by modelling both cognitive and emotional factors influencing AI readiness among pre-service preschool teachers. Although Kölemen and Yıldırım (2025) found that in-service teachers felt unprepared in AI literacy but acknowledged its value for children's development, and Su (2024) identified barriers such as limited teacher knowledge and lack of curriculum support, neither examined how these factors interact structurally. Moreover, Lim (2024) found that pre-service teachers have expressed enthusiasm and concern, seeing AI as an innovative tool and a complex challenge. These mixed views highlight the importance of understanding AI readiness's emotional and psychological aspects. The present study examined the structural relationships between AI literacy, confidence, anxiety, relevance and readiness among pre-service preschool teachers in response to this need. The structural relationships indicate that professional development efforts should look into the emotional aspects to promote pre-service preschool teachers' AI readiness. Insights from this study could inform international educational practices and policymaking, especially regarding the preparation of pre-service preschool teachers for AI-integrated classrooms.

Teachers' perceptions of AI readiness

Integrating AI into educational settings elicits varied responses from teachers. Some enthusiastically embrace its potential to transform teaching and learning, whereas others exhibit scepticism or outright resistance, influenced by factors such as rapid technological evolution, technophobia or doubts regarding technology's efficacy in fostering student learning (Felix, 2020). These perceptions align with the technology acceptance model (TAM; Davis, 1989), which suggests that teachers' acceptance of AI depends on their perceived usefulness and ease of use (C. Zhang et al., 2023). Such factors may significantly influence the effectiveness of AI applications in education, particularly in early childhood education (An et al., 2023; Felix, 2020; Yau et al., 2023). Thus, teachers' AI readiness remains critical when integrating AI into school curricula (Kim & Kwon, 2023). AI readiness among teachers encompasses not only an understanding of the technical aspects of AI but also its practical and ethical applications in the classroom (Celik et al., 2022; Luckin et al., 2022). Based on a survey of 368 teachers, Ayanwale et al. (2022) found that AI readiness significantly predicted teachers' intention to teach AI. Similarly, X. Wang et al. (2023) reported that primary school teachers with higher levels of AI readiness perceived AI as less threatening, which in turn led to increased engagement with AI innovations and greater job satisfaction. Furthermore, Dai et al. (2020) emphasised that enhancing teachers' AI readiness should extend beyond technical knowledge to include emotional and psychological aspects, fostering an environment that promotes AI literacy, AI confidence and AI relevance while simultaneously reducing AI-related anxiety. These four factors are described below.

AI literacy

AI literacy is the ability to acquire and apply AI-related knowledge and skills, emphasising fundamental concepts, attitudes and skills that do not necessitate prior knowledge (Dai et al., 2020; Ng et al., 2021). Various frameworks have been proposed to define AI literacy. Kong et al. (2023) developed an AI literacy

framework encompassing cognitive, affective and sociocultural dimensions. The cognitive dimension emphasises fundamental AI concepts, enabling learners to critically evaluate AI systems and comprehend their real-world implications. The affective dimension focuses on learner empowerment by fostering confidence in engaging with AI. The sociocultural dimension addresses the ethical considerations involved in AI use and development. Similarly, building on Bloom's taxonomy, Ng et al. proposed that AI literacy consists of four key components: knowing and understanding AI, using and applying AI, evaluating and creating AI, and AI ethics. In line with this approach, H. Zhang et al. (2023) introduced an AI literacy framework integrating technical knowledge, ethical awareness and career adaptability to equip individuals with the competencies needed to navigate an AI-driven world. Findings from research have suggested that AI literacy alone does not directly determine AI readiness; rather, its impact is indirectly mediated by individuals' confidence in AI and their perceptions of its relevance (Dai et al., 2020; Henriksen et al., 2025). Furthermore, Dai et al. demonstrated that AI literacy predicts confidence in learning AI and the perceived usefulness and attitudes towards using AI. Thus, we hypothesised that AI literacy fosters confidence and perceived relevance, which in turn predict AI readiness (see Hypotheses 2, 4 & 6).

AI anxiety

Anxiety related to the adoption of AI and technology in education, commonly termed AI anxiety, is a recognised concern among educators (Felix, 2020; Hopcan et al., 2024). Li and Huang (2020) proposed an integrated fear acquisition theory, which identifies key mechanisms underlying AI anxiety: direct trauma or negative experiences during AI interaction, observational learning from others' adverse experiences with AI, information exposure regarding potential AI-related threat and an inherent predisposition to anxiety driven by the uncertainties and unfamiliarity of AI. This framework underscores the multidimensional nature of AI anxiety, highlighting its psychological and social dimensions in addition to technological factors (Li & Huang, 2020). Furthermore, research has demonstrated that AI anxiety among educators in higher education is negatively associated with their AI-related confidence (S. Wang et al., 2023) and their perceptions of AI's usefulness (Sanusi et al., 2024). Given these findings, the present study hypothesised that AI anxiety will negatively predict pre-service preschool teachers' AI literacy, AI confidence, AI relevance and AI readiness (see Hypotheses 1, 3, 5 & 7).

AI confidence

AI confidence refers to teachers' belief in their ability to support and promote AI learning in educational settings (Sanusi et al., 2024). According to Bandura's (1986) self-efficacy theory, individuals with high confidence in their capabilities are more likely to enhance their motivation, effort, and persistence in achieving goals. Research has identified that teachers with greater confidence in using technology perceive it as more useful and easier to integrate into their teaching (Bai et al., 2021). Sanusi et al. (2024) found that teachers with greater confidence are more likely to act on their perception of AI's relevance. Similarly, Jatileni et al. (2024) found that AI confidence predicts teachers' attitudes and intentions towards AI adoption. Thus, based on Bandura's (1986) self-efficacy theory, we proposed a key predictive role for AI confidence (see Hypothesis 8).

AI relevance

The concept of AI relevance is grounded in Keller's (1987) attention, relevance, confidence, satisfaction (ARCS) model, which emphasises that learners are more likely to perceive the material as relevant and engaging when they recognise that the learning environment meets their personal needs and preferences. That is, when teachers see AI as relevant, they are more likely to engage with it and integrate it into their pedagogy. Studies have established that AI relevance positively correlates with AI literacy (Dai et al., 2020) and is a predictive factor for teachers' intentions and positive attitudes towards AI implementation (Jatileni et al., 2024). Research has also indicated that teachers' perceptions of AI relevance positively influence their preparedness for AI integration in educational practices (Ayanwale et al., 2022; Sanusi et al., 2024). Therefore, we hypothesised that AI relevance significantly influences AI readiness and serves as a key factor in teachers' willingness to integrate AI into their teaching practices (see Hypothesis 9).

Instruments for AI readiness

Several instruments assess AI readiness. Ramazanoglu and Akın (2024) developed the Readiness for Artificial Intelligence Applications Scale, measuring teachers' AI readiness across three dimensions: technology self-efficacy, student interaction and ethical awareness, assessing their confidence in AI tools, ability to engage students and awareness of ethical considerations. Similarly, Li and Liang (2025) introduced the Chinese as a Foreign Language Teachers' AI Readiness Scale, which evaluates teachers' propensity to integrate AI into their instruction. This scale consists of three dimensions: personal assets (AI-technological pedagogical content knowledge and technological innovativeness), value-cost beliefs (perceived benefits and costs of AI integration) and contextual resources (institutional support and facilitating conditions). X. Wang et al. (2023) proposed another AI readiness scale for teachers, covering cognition, ability, vision and ethics. Cognition reflects teachers' knowledge of AI in education, ability assesses their competence with AI tools, vision captures their perspective on AI's educational impact, and ethics evaluates their commitment to responsible AI use. Unlike these teacher-centred instruments, Dai et al. (2020) developed a five-dimensional survey assessing students' AI readiness. AI readiness reflects perceived preparedness, while AI literacy measures AI-related knowledge. Confidence in AI captures self-efficacy, relevance assesses perceived usefulness, and AI anxiety explores apprehensions about AI's impact. Although initially designed for students, this instrument is well-suited for pre-service preschool teachers, who, like students, are at an early stage of AI adoption. Their readiness is shaped by literacy, confidence, relevance, and anxiety – key dimensions in Dai et al.'s framework. Since early childhood educators introduce technology to young learners, understanding their psychological and cognitive AI readiness provides critical insights for curriculum development and professional training.

These specific constructs – AI literacy, AI anxiety, AI confidence and AI relevance – were intentionally selected because they directly align with foundational theories relevant to teachers' technology adoption, including TAM (Davis, 1989) and Bandura's (1986) self-efficacy theory. Research has predominantly explored these constructs separately and has not fully captured their interrelated impacts on teachers' readiness to integrate AI, especially in early childhood education settings. Given preschool teachers' unique responsibilities and potentially distinct emotional and cognitive responses towards new technologies, comprehensively understanding these constructs' interplay becomes crucial. Thus, this study contributes significantly to the literature by systematically examining the structural relationships among these cognitive and emotional constructs, thereby offering a nuanced understanding of pre-service preschool teachers' AI readiness.

The literature review highlights links between AI literacy, AI anxiety, AI confidence, AI relevance and teachers' AI readiness. We used structural equation modelling (SEM) to analyse the relationships among these factors. The proposed hypotheses are listed below (Figure 1):

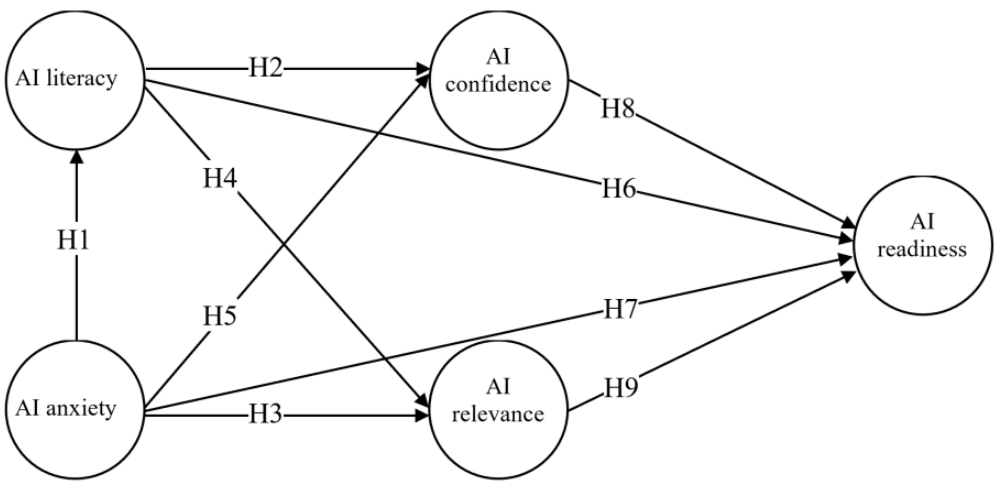

Figure 1. The hypothetical model of the structural relationships

The study addresses the following two research questions (RQs):

- RQ1: Is the instrument developed to assess pre-service preschool teachers' perceived AI readiness valid and reliable?
- RQ2: What are the structural relationships among pre-service preschool teachers' perceived AI literacy, AI anxiety, AI confidence, AI relevance and AI readiness?

To answer these questions, hypotheses were derived based on established theories relevant to technology adoption and emotional and cognitive factors influencing behavioural intentions.
According to the integrated fear acquisition theory (Li & Huang, 2020), anxiety towards technology negatively affects cognitive engagement and motivation. Therefore, we hypothesised:

- Hypothesis 1: Teachers' AI anxiety significantly and negatively predicts their AI literacy.
- Hypothesis 3: Teachers' AI anxiety significantly and negatively predicts their AI relevance.
- Hypothesis 5: Teachers' AI anxiety significantly and negatively predicts their AI confidence.
- Hypothesis 7: Teachers' AI anxiety significantly and negatively predicts their AI readiness.

Drawing on the technology acceptance model (Davis, 1993), which suggests that knowledge about technology (AI literacy) positively influences perceived usefulness (AI relevance) and user confidence, we hypothesised:

- Hypothesis 2: Teachers' AI literacy significantly and positively predicts their AI confidence.
- Hypothesis 4: Teachers' AI literacy significantly and positively predicts their AI relevance.
- Hypothesis 6: Teachers' AI literacy significantly and positively predicts their AI readiness.

Based on Bandura's (1986) self-efficacy theory, which emphasises that confidence in one's ability influences motivation and behavioural engagement, we proposed a mediating role for AI confidence:

- Hypothesis 8: Teachers' AI confidence significantly and positively predicts their AI readiness.

Finally, following Keller's (1987) ARCS model, which highlights that perceived relevance significantly impacts motivation to engage with new material or technologies, we formulated:

- Hypothesis 9: Teachers' AI relevance significantly and positively predicts their AI readiness.

These clearly articulated hypotheses align directly with our research questions and explicitly connect the study's theoretical foundation to its objectives, providing a coherent and robust theoretical basis for empirical testing.

Methodology

Among various existing instruments that measure AI literacy (e.g., Kong et al., 2023; Ng et al., 2021), we specifically selected the questionnaire developed by Dai et al. (2020) because of its comprehensive integration of the following dimensions into a unified AI readiness model: cognitive (AI literacy), emotional (AI anxiety, AI confidence) and motivational (AI relevance). Unlike other well-established instruments, which primarily emphasise either technical understanding of AI (Kong et al., 2023) or ethical and evaluative dimensions (Ng et al., 2021), Dai et al.'s questionnaire explicitly addresses the emotional and psychological factors that are critical for pre-service preschool teachers, whose readiness to adopt AI depends not only on knowledge but also significantly on their confidence, anxiety and perceived relevance. Thus, this holistic measurement approach aligns closely with our study's goal of exploring both cognitive and emotional determinants of AI readiness in early childhood education.

Instruments

The questionnaire measuring pre-service preschool teachers' perceived AI literacy, AI anxiety, AI confidence, AI relevance and AI readiness was adapted from Dai et al.'s (2020) survey items. The five dimensions are described below:

(1) *AI literacy* measured teachers' fundamental AI-related knowledge and skills and consisted of five items. Cronbach's alpha was .90 in Dai et al.'s research. A sample item is, "I can use AI-assisted online translation."
(2) *AI anxiety* measured teachers' anxiety regarding adopting AI technology. Dai et al. adapted the items from Pintrich et al.'s (1993) modified version of the Motivated Strategies for Learning Questionnaire. This factor consisted of five items; Cronbach's alpha was .94 in Dai et al.'s study. A sample item is, "When I think about AI, I feel uneasy."
(3) *AI confidence* assessed teachers' confidence in their ability to excel in AI technology. The Cronbach's alpha value was .89 in Dai et al.'s research. A sample item is, "I believe I can learn the basic concepts in AI class well."
(4) *AI relevance* measured teachers' connection with AI. The Cronbach's alpha value was .91 in Dai et al.'s research. A sample item is, "I know what my future has to do with AI."
(5) *AI readiness* assessed teachers' perspectives on contemporary AI implementations, comprising six items. These items were initially derived from Parasuraman's (2000) Technology Readiness Index. The Cronbach's alpha values were .78 and .92, respectively, in Parasuraman's and Dai et al.'s research. A sample item is, "The new AI technology will stimulate my thinking."

Although the original questionnaire by Dai et al. (2020), which comprised 27 items, was designed for sixth graders, it was necessary to adapt it for pre-service preschool teachers to ensure content validity and relevance to their educational context. The expert committee, which included two professors specialising in early childhood education and one specialising in learning science, revised the wording and focus of certain items to enhance clarity and align with the skills, experiences and instructional practices of pre-service preschool teachers. Additionally, this process involved validating the modified instrument through expert review and consensus-building to enhance its clarity and applicability. These modifications improved the instrument's validity by ensuring that the items accurately reflect the constructs being measured within the target population. All items were assessed using a 5-point Likert scale, with 1 indicating *strongly disagree* and 5 indicating *strongly agree.*

Participants and data collection

This study involved 194 early childhood education majors from seven universities in Taiwan, spanning the northern, central, and southern regions. The gender distribution consisted of 186 females and eight males, reflecting the predominantly female composition of Taiwan's early childhood education field. Participants, on average, engaged with AI-related tools, such as ChatGPT, voice assistants and voice translation technologies, for 2.57 hours each week, with a standard deviation of 4.27 hours. The qualitative data reveal that some participants reported that AI is widely used in learning and education, assisting them in acquiring knowledge, translating content, designing lesson plans and providing immediate answers to facilitate research, making it a valuable tool for structured learning (e.g., ChatGPT). Similarly, others mentioned using personal assistant applications like Siri for quick information retrieval. Furthermore, some participants indicated using AI to generate high-quality digital artwork. Data collection was facilitated through a Google Forms questionnaire, disseminated among participants via email, enabling straightforward online access and completion. The process adhered strictly to ethical requirements: Students were notified that their participation was entirely voluntary and anonymous, with no consequences tied to their choice to participate or decline.

Data analysis

After data collection, confirmatory factor analysis (CFA) was conducted to assess item reliability, internal coherence and construct validity. To understand the factors that predict the AI readiness of pre-service preschool teachers, we employed the partial least squares structural equation modelling (PLS-SEM) method using SmartPLS software version 4. It is effective with relatively small sample sizes, unlike covariance-based SEM, which generally requires larger samples to achieve reliable results (Hair et al., 2021). Thus, a non-parametric bootstrap technique (Hair et al., 2021), which does not require distributional assumptions, is employed. In addition, PLS-SEM, which is capable of flexibly managing a complex prediction model with no identification problems (Hair et al., 2014; Hair et al., 2021), can be smoothly applied across diverse research contexts. Other advanced methods, such as hierarchical linear modelling, were not selected because hierarchical linear modelling is primarily suited for nested hierarchical data structures, such as students within classrooms or schools. Our research design is based on individual-level data without hierarchical structures, making PLS-SEM the most appropriate analytical tool. This method examines the proposed model by addressing nine hypotheses about the relationships among AI literacy, AI relevance, AI confidence, AI readiness and AI anxiety (see Figure 1). We used the PLS algorithm with non-parametric bootstrapping (5,000 resamples) to test the statistical significance of the path coefficients. The metrics, including item factor loadings, Cronbach's alpha, average variance extracted (AVE) and composite reliability (CR) values, were used to assess item reliability, internal consistency and both convergent and construct validity (Hair et al., 2011). Furthermore, we employed Pearson's correlation analysis to discern the interconnections among all scales and to establish the discriminant validity of AI literacy, AI relevance, AI confidence, AI readiness and AI anxiety. Discriminant validity is considered valid if the square root of the AVE exceeds Pearson's correlation coefficient between the factors (Fornell & Larcker, 1981). To test the mediation effects of AI confidence and AI relevance, a bootstrap method, proposed by Preacher and Hayes (2008) and involving a resampling of 5,000 at a 95% confidence level, was utilised, and the analysis of the outcomes was conducted following Zhao et al.'s (2010) mediation typology.

Results

Is the instrument adapted to assess pre-service preschool teachers' perceived AI readiness valid and reliable?

Table 1 presents the CFA results, including the descriptive statistics of the selected items, factor loadings, CR, AVE, and Cronbach's alpha. As shown, the validated items were organised into five latent factors as follows: three items for AI literacy (*Mean* = 3.490, *SD* = .453), four for AI anxiety (*Mean* = 2.457, *SD* = .638), two for confidence in AI (*Mean* = 3.070, *SD* = .545), four AI relevance (*Mean* = 3.119, *SD* = .487) and four for AI readiness (*Mean* = 3.090, *SD* = .453). Overall, 17 items were validated and included in the proposed model. The factor loadings for all items ranged between .724 and .905, with each exceeding .70. Additionally, the CR values for each factor surpassed the recommended minimum of .70, with values ranging from .733 to .927. The AVE values for all factors exceeded the .50 benchmark, falling between .623 and .780. Likewise, Cronbach's alpha values for each factor were between .720 and .830, exceeding the suggested threshold of .70. These indices align with the recommendations set forth by Hair et al. (2011).

Table 1
Results of the CFA and reliabilities of the AI factors (N = 194)

Dimensions & items	Factor loading	CR	AVE	Cronbach's alpha
AI literacy (LI), *Mean* = 3.490, *SD* = .453		.809	.724	.806
LI1. I know that AI can be used for image recognition and searching.	.875			
LI2. I know that AI can be used for speech recognition and searching.	.905			
LI3. I will use AI-assisted online translation.	.768			
AI anxiety (AN), *Mean* = 2.457, *SD* = .638		.927	.640	.830
AN1. I am worried that AI will bring trouble to my future.	.828			
AN2. I am worried that my future will fail because of AI.	.767			
AN3. When I think about AI, I feel uneasy.	.834			
AN4. I feel very pressured to hear about the advancement of AI technology.	.768			
AI confidence (CO), *Mean* = 3.070, *SD* = .545		.733	.780	.720
CO1. I believe that I can learn the AI course well as long as I work hard.	.863			
CO2. I believe I can learn the basic concepts in the AI class well.	.903			
AI relevance (RE), *Mean* = 3.119, *SD* = .487		.802	.623	.799
RE1. Learning AI-related knowledge is very useful for me.	.839			
RE2. I should learn the basics of AI.	.785			
RE3. The content of the AI course is related to my interests.	.768			
RE4. I can connect AI with everyday life outside the classroom.	.764			
AI readiness (RD), *Mean* = 3.090, *SD* = .453		.834	.652	.821
RD1. I like to use advanced AI technology.	.856			
RD2. Technology can help me adjust things to meet my needs.	.858			
RD3. The new AI technology will stimulate my thinking.	.782			
RD4. I am confident that AI technology will do things following my instructions.	.724			

Correlations among the factors and the discriminant validity

Table 2 presents the correlation matrix and the square root of the AVE values for each factor within the AI scales. The data show that all factors, except AI anxiety, were significantly correlated (r = .367 - .639, p < .01). AI anxiety exhibited a statistically significant negative relationship with AI readiness (r = -.243, p < .05). Regarding discriminant validity, the square root of the AVE value for each factor, which ranged from .79 to .883, exceeded .50 and surpassed Pearson's correlation coefficients between each factor and the rest. This confirms the discriminant validity of the five factors in the AI scale (Hair et al., 2011). In addition, the heterotrait-monotrait values were also below the threshold of 0.85, demonstrating adequate discriminant validity (Henseler et al., 2015).

Table 2
Discriminant validity using the Fornell-Larcker criterion and HTMT

Constructs	1.	2.	3.	4.	5.
1. AI literacy	**0.851**				
	(–)				
2. AI anxiety	-0.137	**0.800**			
	(0.121)	(–)			
3. AI confidence	0.382**	-0.143	**0.883**		
	(0.151)	(0.302)	(–)		
4. AI relevance	0.474**	-0.118	0.639**	**0.790**	
	(0.250)	(0.613)	(0.446)	(–)	
5. AI readiness	0.367**	-0.243*	0.504**	0.580**	**0.807**
	(0.155)	(0.772)	(0.581)	(0.707)	(–)

Note. The bold numbers on the diagonal represent the square root of the AVE (Fornell-Larcker criterion). Numbers below the diagonal are correlation coefficients between constructs. Numbers in parentheses represent the HTMT values.

*p < .05. **p < .01.

What are the structural relationships among pre-service preschool teachers' perceived AI literacy, AI anxiety, AI confidence, AI relevance and AI readiness?

Figure 2 and Table 3 present the structural relationships among various AI scale factors as reported by the pre-service preschool teachers. As shown in Table 3, the findings indicated that participants' AI literacy was significantly and positively associated with both AI confidence (path coefficient = .370, p < .001) and AI relevance (path coefficient = .466, p < .001). These factors, in turn, were also related to AI readiness, indicated by path coefficients of .196 (p < .05) for AI confidence and .397 (p < .001) for AI relevance. Conversely, AI anxiety is associated with a lower level of AI readiness, demonstrated by a path coefficient of -.157 (p < .05). These associations highlight the complex interplay between cognitive and emotional elements in shaping pre-service preschool teachers' readiness for AI-enhanced learning environments. Thus, Hypotheses 2, 4, 7, 8 and 9 were supported.

To further evaluate the predictive capability of the structural model, we assessed the predictive relevance (Q^2) using a blindfolding procedure. Q^2 values larger than 0 indicate that the model has adequate predictive relevance. The results reveal that the Q^2 values for the AI literacy (0.001), AI confidence (0.001), AI relevance (0.004), and AI readiness (0.032) dimensions are positive, indicating that the model demonstrates predictive validity for all dimensions (Hair et al., 2021).

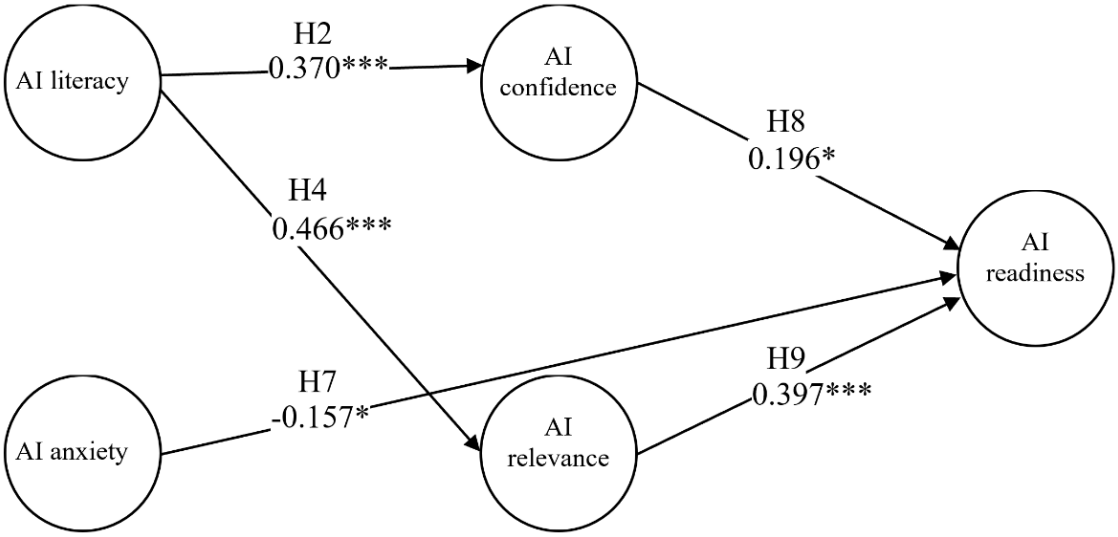

Figure 2. Structural relationships among the factors of the AI scale for pre-service preschool teachers.
Note. *p < .05. ***p < .001.

Table 3
Path coefficients of the model

Hypothesis	Path	Estimate	Standardised weight	*t* statistics	Q squared	Hypothesis supported ?
H1	AI anxiety → AI literacy	-0.137	0.080	1.725	0.001	No
H2	AI literacy → AI confidence	0.370	0.055	6.733***	0.001	Yes
H3	AI anxiety → AI relevance	-0.054	0.089	0.608	0.004	No
H4	AI literacy → AI relevance	0.466	0.049	9.470***	-	Yes
H5	AI anxiety → AI confidence	-0.092	0.085	1.082	-	No
H6	AI literacy → AI readiness	0.083	0.059	1.396	0.032	No
H7	AI anxiety → AI readiness	-0.157	0.073	2.153*	-	Yes
H8	AI confidence → AI readiness	0.196	0.078	2.515*	-	Yes
H9	AI relevance → AI readiness	0.397	0.101	3.936***	-	Yes

*p < .05. ***p < .001.

To assess whether AI confidence and AI relevance mediated the relationship between AI literacy and AI readiness, we conducted the bootstrapping method with a sample size of 5,000 and a 95% confidence interval, as recommended by Preacher and Hayes (2008). Table 4 shows that the path from AI literacy directly to AI readiness (direct effect, path estimate = 0.083, p > .05) was not statistically significant. However, both the path from AI literacy through AI confidence to AI readiness (indirect effect, path estimate = 0.072, p < .05) and the path from AI literacy through AI relevance to AI readiness (indirect effect, path estimate = 0.185, p < .001) were statistically significant. According to Zhao et al. (2010), these findings suggest an indirect-only mediation model. In other words, although teachers' perceptions of AI literacy did not directly predict AI readiness, developing their AI literacy can enhance their AI confidence and AI relevance, which, in turn, improves their AI readiness.

Table 4
The results of the mediation analysis

Path	Estimate	Standardised weight	*t* statistics
Direct effect			
AI literacy → AI readiness	0.083	0.059	1.396
Indirect effect			
AI literacy → AI confidence → AI readiness	0.072	0.032	2.283*
AI literacy → AI relevance → AI readiness	0.185	0.051	3.601***

*$p < .05$. ***$p < .001$.

Discussion

The mediating roles of AI confidence and AI relevance

The findings of this study significantly advance our theoretical understanding of AI readiness and its related emotional and cognitive constructs, specifically within early childhood teacher education contexts. First, our results underscore the essential mediating roles of AI confidence and AI relevance in the relationship between AI literacy and AI readiness. This supports and extends previous theoretical frameworks, such as Bandura's (1986) self-efficacy theory and Keller's (1987) ARCS model, by emphasising emotional and motivational dimensions as critical mediators in technology adoption processes. Additionally, by confirming the negative role of AI anxiety through the lens of the integrated fear acquisition theory (Li & Huang, 2020), our study expands the theoretical discourse by highlighting the complex interplay between cognitive understanding and emotional barriers in AI integration.

The unique context of early childhood AI education

AI integration in pre-service early childhood teacher education differs from other educational stages and plays a crucial role in shaping young children's digital literacy. Early childhood is a critical period for establishing foundational skills, and introducing AI concepts at this stage can support cognitive development and technological adaptability in an increasingly AI-driven world (Su, 2024; Yang, 2022). Since pre-service preschool teachers serve as facilitators of exploratory learning rather than direct AI instruction, their perceptions of AI significantly influence how young children engage with digital technologies and develop AI proficiency (An et al., 2023; Felix, 2020). At the college level, pre-service preschool teachers are trained to integrate AI into inclusive, engaging and developmentally appropriate learning environments rather than design, develop or critically evaluate AI technologies. In contrast, AI integration in secondary and higher education focuses on enhancing subject-specific knowledge, test preparation or career readiness. Given the importance of AI in early education, understanding pre-service preschool teachers' AI readiness is essential for designing effective training programmes. The present study aimed to validate an instrument for assessing pre-service preschool teachers' AI readiness and related psychological factors while further examining the structural relationships among these factors.

Theoretical contributions: Refining the construct of AI readiness

The first theoretical contribution of this study includes the refinement of AI readiness constructs. The outcomes from the PLS-SEM demonstrate that the constructed model was a suitable fit for the data. The questionnaire adapted and used in this study showed sufficient reliability and convergent validity regarding the measurement model. Hence, the study contributes to current research on AI literacy in early childhood. Particularly, research has mainly examined AI readiness in the contexts of general education (X. Wang et al., 2023; Sanusi et al., 2024) and workforce training (Suseno et al., 2022). This study expands the conceptual framework by focusing on pre-service preschool teachers, a population that has been largely overlooked in AI literacy research.

The importance of emotional engagement

The second contribution of this study is highlighting the crucial mediating roles of AI confidence and AI relevance in bridging AI literacy with AI readiness. This indicates a distinct pattern: cognitive comprehension of AI (represented by AI literacy) may not directly translate into an inclination or readiness to engage with AI without including emotional engagement and perceived usefulness (embodied by confidence and relevance, respectively). This emphasises the necessity for an integrative strategy for designing AI educational initiatives, particularly those aimed at early childhood education. Hence, it is inadequate for educators and students to merely be knowledgeable about AI; they must also appreciate its tangible utility and feel assured in its application. This insight is echoed by research suggesting that fostering AI literacy in primary schoolers can strengthen their confidence and perceived utility of AI, which, in turn, might enhance their AI readiness (Dai et al., 2020). Similarly, the findings correspond with Lim's (2023) study, which examined the effects of digital literacy and self-efficacy on AI education perceptions among 236 pre-service preschool teachers. The results identified self-efficacy as a key mediating factor between digital literacy and perceptions of AI, indicating that teachers with higher confidence in their capabilities are more inclined to participate in AI education.

AI anxiety and the neutral attitudes of pre-service teachers

Last, this study advances the theoretical understanding of AI anxiety as a critical factor negatively influencing AI readiness in education, particularly within the under-explored context of pre-service preschool teachers. Research has indicated that higher levels of AI anxiety are generally associated with a lower inclination and readiness to engage with, learn about and implement AI in class (Hopcan et al., 2024; Jabali et al., 2025; Sanusi et al., 2024). In assessing pre-service preschool teachers' concerns regarding the adoption of AI technology, the AI anxiety factor yielded a mean score of 2.46 (*SD* = .64). It is important to note that on a 5-point scale, a score of 3 indicates neutrality, with any score below this suggesting a level of concern below neutral. Despite the lack of AI professional development among pre-service early childhood teachers in Taiwan, significant anxiety regarding AI's impact was not evident. This could be because educators in early childhood education prioritise childcare-related activities, an area less likely to be immediately substituted by AI. Thus, this neutrality, marked by neither strong anxiety nor considerable confidence (*Mean* = 3.070, *SD* = .545), may hinder their readiness to integrate AI into their teaching practices. Although teachers are not overwhelmingly anxious about incorporating AI, their lack of confidence could hinder their adoption and effective use of AI in early childhood education. Teachers who remain neutral may be less inclined to explore, learn about or implement AI tools in their pedagogy, potentially delaying AI's benefits in educational environments. This is where pre-service preschool teachers appear to diverge from their peers in other teaching domains (e.g., Chai et al., 2023).

Practical implications

This study has three practical implications for pre-service preschool teachers' training programmes. First, given the positive association between AI literacy and AI confidence and relevance, teacher training programmes should prioritise enhancing AI literacy with a focus on building teachers' confidence and demonstrating the relevance of AI. This can involve integrating AI-related content into the curriculum, providing hands-on experience with AI tools, and fostering fundamental AI-related knowledge and skills (Yang, 2022). Second, the negative correlation between AI anxiety and AI readiness highlights the need to address emotional barriers in teacher training. Research has indicated that teachers might have misconceptions about AI capabilities. Their high expectations of what AI can do constantly result in fear and anxiety (Velander et al., 2023).

That is, teacher training programmes must emphasise educating teachers about what AI can and cannot do, which can help reduce anxiety and improve pre-service teachers' AI readiness. Although this may not apply to pre-service preschool teachers, they need to keep track of the development of AI, especially in the case of foreign language learning, as AI may help. In the early childhood education context, AI can be employed in various contexts. For example, AI can analyse young children's emotional state to help

teachers plan appropriate activities. Meaningful potential uses of AI are an area that early childhood educators should further explore.

Overall, this study moves beyond intuitive recommendations by providing empirically validated structural insights into the critical emotional and cognitive dimensions influencing pre-service preschool teachers' AI readiness. By explicitly identifying and validating the mediating roles of AI confidence and relevance within a theoretically rigorous framework, our findings offer concrete theoretical advances and practical guidance that extend beyond general suggestions found in the literature.

Limitations of the study

This study has several limitations. First, the relatively small sample size (N = 194) from only seven universities in Taiwan limits the generalisability of our findings. A more extensive and diverse sample would strengthen the external validity and applicability across various educational and cultural contexts. Second, the dimension of AI literacy examined in this study primarily focuses on fundamental AI-related knowledge and skills, such as AI-assisted translation, potentially overlooking more sophisticated cognitive and practical AI competencies that pre-service preschool teachers may require, thus limiting a comprehensive assessment of AI readiness. Chee et al. (2025) have proposed a structured AI literacy framework that progresses from basic tool operation to advanced AI-based problem-solving and critical thinking skills, indicating that future research should employ more sophisticated instruments to holistically assess AI literacy, capturing technical proficiency and the capacity to apply AI in complex, real-world scenarios.
Third, as a cross-sectional study, our findings reflect a single point in time, restricting our ability to draw causal inferences regarding the relationships among the studied variables. Future longitudinal research could better illuminate the causal dynamics and temporal changes in pre-service teachers' perceptions and readiness related to AI integration. Fourth, although AI anxiety encompasses multiple dimensions, such as learning anxiety, job replacement anxiety, socio-technical blindness anxiety and AI configuration anxiety (Hopcan et al., 2024), this study did not differentiate these anxiety types, potentially limiting the comprehensiveness of our findings. Future research should explore these dimensions individually and develop targeted strategies to mitigate their specific impacts.

Additionally, this research aligns with UNESCO's AI competency framework for teachers (Cukurova & Miao, 2024), emphasising structured AI competency development. UNESCO categorises AI competency into three levels: acquire (fundamental AI literacy and ethical implications), deepen (enhanced pedagogical integration and ethical AI use) and create (advanced AI applications and inclusive policy advocacy). Given that our study primarily addresses the acquisition stage, further research should explore pre-service teachers' AI readiness at more advanced competency levels.

Moreover, recognising that pre-service preschool teachers might vary significantly in their prior AI awareness and understanding, this study used CFA and PLS-SEM, methodologies designed to account statistically for individual differences in responses. However, explicit categorisation or measurement of participants' baseline AI knowledge or experience was not conducted. Future studies could incorporate pre-assessments or cluster analyses to explicitly categorise participants based on prior AI knowledge, thus providing deeper insights into how varying degrees of AI familiarity influence AI readiness.

Lastly, effective and efficient pedagogical strategies for AI integration remain underexplored. Given the complexity and evolving nature of AI, additional research is needed to identify and validate instructional methodologies and practical approaches for AI integration in educational contexts.

Directions for future research

Future research could extend this study by employing experimental or quasi-experimental designs to test specific interventions to reduce AI anxiety or enhance AI literacy among diverse educational populations, including cross-cultural comparisons to identify broader implications. Further studies should investigate practical instructional strategies or specific AI tools, such as generative AI (e.g., ChatGPT) or AI-driven

analytics, that effectively build teachers' AI confidence and perceived relevance, potentially employing case studies or action research in authentic classroom environments. Additionally, we recommend empirical evaluations of professional development interventions, such as targeted workshops or AI simulation activities explicitly designed to reduce distinct AI anxiety dimensions among pre-service teachers. Finally, longitudinal studies should be conducted to track changes in pre-service teachers' AI literacy, confidence, anxiety and readiness throughout their professional development. This will provide deeper insights into how these perceptions evolve and influence teaching practices.

Author contributions

Chung-Yuan Hsu: Data curation, Data analysis, Writing – original draft, Writing – review and editing; **Ching Sing Chai**: Investigation, Writing – review and editing; **Jyh-Chong Liang**: Conceptualisation, Data analysis, Writing – review and editing.

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