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PRESERVICE SCIENCE TEACHERS' PREPAREDNESS FOR INTEGRATING AI IN SCIENCE TEACHING: A STRUCTURAL EQUATION MODELING APPROACH

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Abstract

The integration of artificial intelligence (AI) in science education is becoming increasingly essential; however, research on preservice science teachers' preparedness for AI adoption remains scarce. This study addressed this gap by examining the factors influencing AI integration readiness using a Structural Equation Modeling (SEM) approach. Data were collected from 350 preservice science teachers in private and public higher education institutions through a structured survey. The SEM results revealed that prior technology experience significantly predicted AI readiness ($\beta = 0.257$, $p < 0.001$), confidence in learning AI ($\beta = 0.273$, $p < 0.001$), and self-transcendent goals ($\beta = 0.267$, $p < 0.001$). Additionally, attitude towards AI strongly influenced AI readiness ($\beta = 0.504$, $p < 0.001$) and confidence in learning AI ($\beta = 0.338$, $p < 0.001$). Engagement in AI learning emerged as the strongest predictor of preparedness for AI integration ($\beta = 0.803$, $p < 0.001$). These findings underscore the significance of AI-focused teacher training programs and experiential learning approaches in enhancing AI competency. The study emphasizes the importance of curriculum enhancements in promoting AI engagement and mitigating AI-related anxiety, thereby ensuring that future educators are well-prepared for AI-driven pedagogy in science education.

Keywords – AI integration, Preservice science teachers, Science teaching, Structural equation modeling (SEM).

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1. Introduction

The rapid progress of Artificial Intelligence (AI) is reshaping industries, including education. The field of science education can significantly benefit from AI's ability to tailor learning experiences for individuals, provide feedback, and analyze scientific information (Yılmaz, 2024). The seamless incorporation of AI into teaching science depends on the readiness of science educators (Zawacki-Richter, Marín, Bond & Gouverneur, 2019).

According to recent studies, the use of artificial intelligence (AI) in education highlights the importance of preparing science teachers to effectively integrate this technology (Akinwalere & Ivanov, 2022). Although AI tools can potentially enhance teaching methods and personalize student learning experiences in classrooms, today's educators often feel unprepared to incorporate these advancements due to factors such as a lack of familiarity with AI systems, insufficient training, and inadequate institutional support. This highlights the necessity for comprehensive professional development initiatives designed to address these challenges. Studies have shown that AI technology enhances students' academic performance and tailors their learning experiences to their individual needs (Almasri, 2024). Upcoming teachers frequently feel unsure about incorporating AI into their teaching practices. Preservice science teachers could benefit from specialized training and support (Bautista, Estrada, Jaravata, Mangaser, Narag, Soquila et al., 2024). Exploring the factors that impact teachers' readiness, through the Technology Acceptance Model, can help shape programs and professional growth opportunities (Zhang, Schießl, Plößl, Hofmann & Gläser-Zikuda, 2023). Recent research has shown that students' perceptions of AI's value and their readiness to use AI-based tools are greatly influenced by their awareness, attitudes, and trust in the technology (Arroyo-Sagasta, Anton, Zuberogoitia & Egaña, 2025), highlighting the importance of psychological and affective factors in AI readiness. To tackle these shortcomings, it will prepare teachers in an efficient way to make the most of AI in science classrooms successfully.

Preservice teachers' preparedness to integrate AI into their teaching methods is influenced by their engagement and attitudes towards AI technologies. Studies indicate that a positive attitude towards AI enhances their acceptance and willingness to adopt these tools in educational settings, while negative perceptions can hinder effective integration (Papadakis & Kalogiannakis, 2020; Pokrivcakova, 2023). Furthermore, understanding the factors that shape their engagement is crucial for developing effective teacher education programs that equip them with the necessary AI competencies (Ayanwale, Frimpong, Opesemowo & Sanusi, 2025). According to a recent comparative analysis by Lucas, Bem-Haja, Zhang., Llorente-Cejudo and Palacios-Rodríguez (2025), the preparedness of preservice teachers to integrate AI varies across different educational contexts. These variations are frequently associated with institutional emphasis, teacher training opportunities, and access to AI resources. Similarly, Şahín (2024) highlights that ethical considerations and responsible implementation should also be integral to the integration of AI in education. This will ensure that educators develop the professional and moral awareness necessary to mentor students in the responsible use of AI, in addition to the technological proficiency required.

Despite the available research on preservice teacher education, gaps remain in understanding the specific factors that contribute to preservice science teachers' preparedness for integrating AI into science teaching. Current literature often lacks detailed investigations into how AI-related knowledge, confidence, and institutional support influence readiness. Further research is necessary to explore these areas, particularly in diverse teaching environments, to understand the potential challenges and enablers of AI integration. Addressing these gaps would provide educators and policymakers with actionable insights to enhance teacher training programs, ensuring preservice teachers are equipped to meet the demands of modern science education. Furthermore, additional studies are needed to investigate the combined effects of AI literacy and pedagogical innovation in promoting successful integration in science classrooms, particularly within preservice teacher training.

This study examined the preparedness of preservice science teachers to integrate artificial intelligence (AI) in science instruction through a structural equation modeling approach. It identified and analyzed the factors influencing their readiness to incorporate AI technologies into their teaching practices, focusing on both technological and pedagogical competencies. Furthermore, the study examined the interactions among these factors to assess their combined impact on the integration of AI in science education. The findings are anticipated to offer practical implications for science teacher education programs, guiding the development of strategies that enhance AI-related competencies among future science educators.

1.1. Hypotheses Development and Literature Review

1.1.1. Prior Technology Experience (PTE)

Prior technology experience is a foundational factor influencing teachers' comfort and readiness to adopt AI. Individuals with greater exposure to digital tools generally experience lower anxiety towards new technologies (Wen, Li, Zhou, An & Zou, 2024; Kaya & Bulut, 2022) and show higher confidence in learning and using AI (Wang, Wei, Lin, Wang & Wang, 2024; Zhang et al., 2023). Moreover, PTE enhances teachers' AI readiness, providing a base for skill development and pedagogical innovation (Yue, Jong & Ng, 2024; Bautista et al., 2024). It also promotes self-transcendent goals, as technologically experienced individuals are more likely to see AI as a means to serve broader educational and societal purposes (Ayanwale et al., 2025; Huang & Katz, 2025). Hence, the following hypotheses are proposed:

H1: Prior Technology Experience has a significant direct effect on Anxiety Towards AI.
H2: Prior Technology Experience has a significant direct effect on AI Readiness.
H3: Prior Technology Experience has a significant direct effect on Self-Transcendent Goals.
H4: Prior Technology Experience has a significant direct effect on Confidence in Learning AI.

1.1.2. Attitude Towards AI

Attitude towards AI strongly shapes how preservice teachers perceive and interact with AI technologies. A positive attitude reduces anxiety (Wang et al., 2024; Mahdi & Sahari, 2024), enhances AI readiness and confidence (Shahat, Al-Balushi & Al-Amri, 2022; Wen et al., 2024), and increases engagement in AI-related learning activities (Koehler, Cheng, Fiock, Wang, Janakiraman & Chartier, 2022). Teachers with favorable views of AI are also more likely to develop self-transcendent goals, aligning technology use with their sense of purpose and contribution to society (Damon, Menon & Bronk, 2003; Zhang et al., 2023). Accordingly, the following hypotheses are posited:

H5: Attitude Towards AI has a significant direct effect on Anxiety Towards AI.
H6: Attitude Towards AI has a significant direct effect on AI Readiness.
H7: Attitude Towards AI has a significant direct effect on Self-Transcendent Goals.
H8: Attitude Towards AI has a significant direct effect on Confidence in Learning AI.
H9: Attitude Towards AI has a significant direct effect on Engagement in Learning AI.

1.1.3. Anxiety Towards AI

Anxiety towards AI significantly impacts students' engagement in learning AI. Research indicates that anxiety related to AI can negatively impact students' motivation and engagement in educational settings, resulting in diminished learning outcomes (Zhang et al., 2023). The development of an artificial intelligence anxiety scale has shown a clear correlation between AI anxiety and motivated learning behavior, suggesting that addressing these anxieties is crucial for ensuring positive learning outcomes in technology-enhanced education. Furthermore, the psychological effects of AI anxiety highlight the need for educational strategies that mitigate these concerns to foster a more engaging learning environment (Kim, Kadkol, Solomon, Yeh, Soh, Nguyen et al., 2023). Thus, it is hypothesized that:

H10: Anxiety towards AI has a significant direct effect on Engagement in Learning AI.

1.1.4. AI Readiness

AI readiness encompasses a teacher's familiarity with AI concepts, confidence in utilizing these technologies, and the perceived relevance of AI to their teaching practices (Popenici & Kerr, 2017).

Research indicates that higher learner engagement with AI is associated with a greater likelihood of its use in the classroom (Kim & Kim, 2022). Through SEM, researchers can examine the intricate interaction between variables, such as AI readiness and engagement, and how these factors, combined, affect teachers' preparedness to use AI in teaching (Wang, Li, Tan, Yang & Lei, 2023). Thus, it is hypothesized that:

H11: AI Readiness has a significant direct effect towards Engagement in Learning AI.

1.1.5. Self-Transcendent Goal

Engagement in learning AI among preservice science teachers is often linked to their personal motivations and aspirations. Research shows that teachers with strong self-efficacy and intrinsic goals (fostering student growth) are more likely to engage with and adopt digital tools effectively (Wang et al., 2024). Additionally, goal orientation, particularly towards collaborative and student-centered teaching, boosts motivation to integrate AI tools (Treve, 2024). Understanding how internal motivations, such as personal growth and societal impact, drive engagement is also central (Kim et al., 2023). Preservice science teachers with strong self-transcendent motivations may demonstrate higher engagement and persistence, which are essential for adopting AI into their future teaching (Ding, Shi, Yang & Choi, 2024). Therefore, it is hypothesized that:

H12: Self-Transcendent Goal has a direct effect on Engagement in Learning AI.

1.1.6. Confident in Learning AI

Studies demonstrate that self-efficacy is one of the most important motivators for teachers to adopt new technologies, as individuals with high self-efficacy tend to devote more time and energy to learning complex subjects (Bandura, 1997). Other researchers have shown that teachers who acknowledge the specific practical advantages of technology are reported to be more engaged and motivated about learning how to use technology effectively in the classroom (David & Weinstein, 2024). Research further suggests that when educators feel confident in their technological skills and understanding, they are more likely to integrate AI effectively into their teaching practices, thereby fostering a more engaging learning environment for both themselves and their students (Kim & Kim, 2022). Thus, it is hypothesized that:

H13: Confident in Learning AI has a significant direct effect towards Engagement in Learning AI.

1.1.7. Engagement in Learning AI

Engagement in learning AI has a significant direct effect on preparedness for integrating AI in science teaching. Research indicates that when educators actively engage with AI technologies, they develop essential skills and confidence that enhance their ability to integrate these tools into their teaching practices (Zhang et al., 2023). Engagement not only fosters a deeper understanding of AI but also equips teachers with the pedagogical strategies necessary for effective implementation in science education (Budiman & Syafrony, 2023). Furthermore, studies show that higher levels of engagement correlate with increased readiness to adopt innovative teaching methods that incorporate AI, ultimately leading to improved educational outcomes (Yilmaz & Yilmaz, 2023). Thus, it is hypothesized that:

H14: Engagement in learning AI has a significant direct effect on preparedness for integrating AI in science teaching.

The above hypothesized relationships illustrate how prior technology experience, attitudes, anxiety, readiness, self-transcendent goals, confidence, and engagement collectively contribute to enhancing the preparation of preservice science teachers for AI.

These relationships are conceptually aligned with the Artificial Intelligence Technological Pedagogical and Content Knowledge (AI-TPACK) framework, which builds on the traditional TPACK model by highlighting teachers' integration of AI-specific technological, pedagogical, and ethical competencies (Ning, Zhang, Xu, Zhou & Wijaya, 2024; Saharuddin, Nasir & Mahmud, 2025). This integration is reflected in the current study's model, where prior technology experience corresponds to the technological knowledge domain. At the same time, the pedagogical and affective dimensions are represented by engagement and attitudes that shape instructional practices and motivation. Confidence in learning AI and AI readiness align with pedagogical-technical fluency, indicating teachers' ability to apply AI tools effectively in learning contexts. Meanwhile, AI-related anxiety and self-transcendent goals are related to the ethical and reflective dimensions of AI-TPACK, as they reflect teachers' awareness of AI's broader implications and their motivation to use it responsibly and purposefully. Thus, the proposed model operationalizes the multidimensional nature of AI-TPACK by linking technological experience, attitudes, emotional and motivational factors, and reflective awareness to preservice science teachers' preparedness for AI integration.

The proposed model resulting from the study (Figure 1) illustrates these relationships and serves as the basis for the empirical analysis presented in this study.

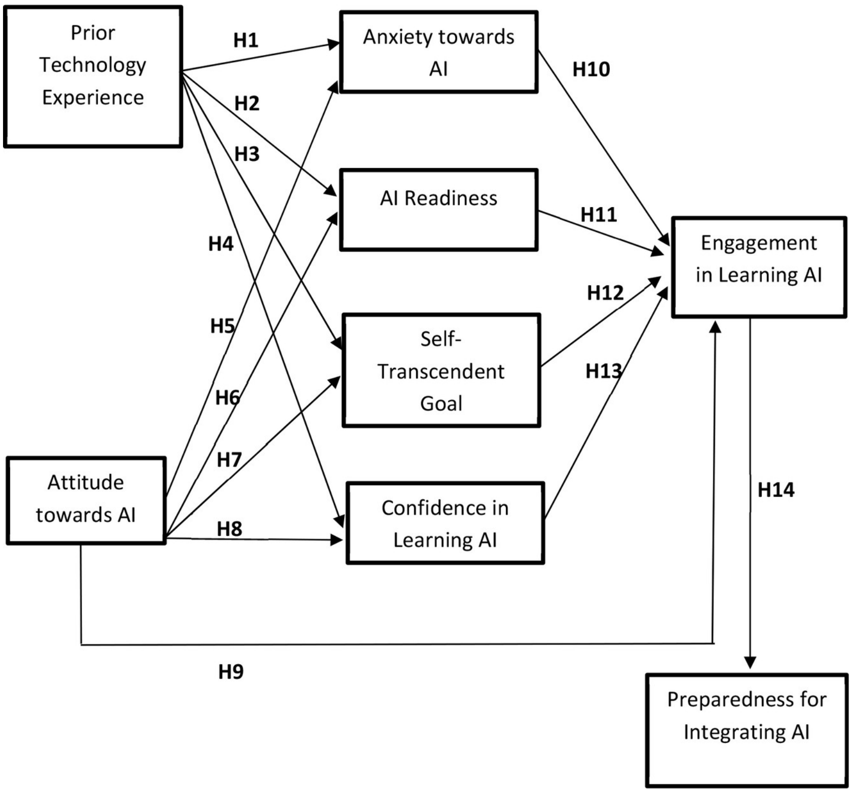

Figure 1. Proposed Model of the Study

2. Methodology

2.1. Design

The study employed a cross-sectional research design, utilizing a Structural Equation Modeling (SEM) approach, to investigate the factors influencing preservice science teachers' preparedness for integrating Artificial Intelligence (AI) in science education teaching. The research design tested a theoretical model that hypothesized relationships between these variables. Structural Equation Modeling (SEM) enables simultaneous analysis of direct and indirect effects between variables (Thakkar, 2020; Zhang, 2022), providing a comprehensive understanding of the interplay between factors that influence preservice science teachers' preparedness for integrating AI.

2.2. Participants

The study's participants were the preservice teachers studying education in a college department majoring in science within Cebu, Philippines, specifically, State Universities and Colleges (SUCs) and Private Higher Education Institutions (PHEIs). A controlled quota sampling method was employed in this study to gather data from 369 participants across both public and private institutions at any year level for the academic year 2024-2025. A controlled quota is used to increase the validity of the respondents. Several specific criteria are applied in selecting samples after defining the population (Futri, Risfandy & Ibrahim, 2022).

Variables	Statistical Population	Percent (%)
Age		
Below 18	18	4.88
18-20	155	42.01
21-24	137	37.13
25-above	59	15.99
Sex		
Female	271	73.44
Male	98	26.56
Year Level		
First Year	87	23.58
Second Year	72	19.51
Third Year	67	18.16
Fourth Year	101	27.37
Graduate	42	11.38

Table 1. Demographic Profile of the Respondents (n=369)

2.3. Instruments

The data were collected using an adapted questionnaire that employed a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The instrument was derived from previously validated tools and was refined through expert review and confirmatory factor analysis (CFA) to ensure construct validity. This study utilized eight latent constructs: prior technology experience, attitudes towards AI, anxiety towards AI, AI readiness, self-transcendent goal, confidence in learning AI, engagement with AI-based tools, and preparedness for AI integration in science teaching. Prior technology experience was measured using four items adapted from Hatlevik, Guðmundsdóttir and Loi (2015), such as "Used an instant messenger." Teachers' attitudes towards AI and AI-related anxiety were measured using items adapted from the validated scale of Çayak (2024), which explicitly targets educators' AI dispositions and literacy. Constructs related to AI readiness, self-transcendent goals, and confidence in learning AI were adapted from Ma'amor, Achim, Ahmad, Roszaman, Kamarul-Anuar, Khairul-Azwa et al. (2024), featuring sample items like "I wish to use my AI knowledge to serve others." Additionally, acceptance-related items were adapted from Runge, Hebibi and Lazarides (2025), whose study incorporated the Technology Acceptance Model (TAM) and AI-TPACK to evaluate preservice teachers' readiness and training in AI integration. Only items that passed the CFA loadings were retained for the final instrument.

2.4. Procedure

A questionnaire survey was conducted to assess the preparedness of pre-service science teachers for integrating AI into their teaching practices. Following approval of the study, an informed consent form was distributed online, clearly outlining the study's purpose, the voluntary nature of participation, participants' rights, and the option to withdraw at any time.

The data collected was exported to spreadsheets for analysis. To ensure data security, the spreadsheets were stored on USB drives and personal computers with password protection. Participants were assured of the confidentiality and anonymity of their responses, as each was assigned a unique code. Hard copies of the informed consent forms and any related documents were securely stored in locked cabinets. Throughout the research process, ethical standards were upheld to protect participants' privacy and the integrity of the data collected, following guidelines established in prior research aligned with the Philippine Republic Act 10173, also known as the Data Privacy Act of 2012.

2.5. Data Analysis

The data gathered were checked for internal consistency to measure whether items within the same construct were related (Hajjar, 2018). To improve internal consistency, items with lower intercorrelations were eliminated between those linked to the measures and those representing other measures. After ensuring internal consistency, construct validity, and determining a good fit for the proposed model, a final test on the structural model was conducted using bootstrapping. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software. SmartPLS SEM version 4 was employed to provide a comprehensive understanding and connections among the various factors and behaviors depicted in a structural model (Hair, Ringle, Danks, Hult, Sarstedt & Ray, 2021; Henseler, Ringle & Sarstedt, 2015; Ringle, Wende & Becker, 2024).

3. Results

The measurement model assessment results demonstrate strong reliability and validity across constructs related to AI readiness, attitudes, and learning engagement. Most factor loadings (FL) exceed the 0.70 threshold (Hair, Risher, Sarstedt & Ringle, 2019), indicating good item reliability, while Cronbach's alpha (α) and composite reliability (CR) values are above 0.70, confirming internal consistency (Fornell & Larcker, 1981). AI Readiness (CR = 0.902, α = 0.900) and Preparedness in Integrating AI (CR = 0.916, α = 0.914) demonstrate particularly high reliability, indicating a robust measurement of these constructs. The average variance extracted (AVE) values for all constructs exceed 0.50, confirming convergent validity (Hair et al., 2021). Notably, Anxiety towards AI (AVE = 0.741) exhibits the highest variance explained, implying that its indicators strongly represent the underlying construct. However, Prior Technology Experience (CR = 0.694, α = 0.694, AVE = 0.531) falls slightly below the ideal threshold, suggesting the need for potential refinement or additional measurement items (Henseler et al., 2015).

The Heterotrait-Monotrait (HTMT) ratio of correlations assesses discriminant validity, ensuring that constructs are distinct from one another (Henseler et al., 2015). Generally, HTMT values below 0.85 indicate acceptable discriminant validity, while values above 0.90 suggest potential issues (Hair et al., 2019). In this study, most HTMT values remain within the acceptable range, confirming adequate discriminant validity among constructs. Notably, Engagement in Learning AI (ELA) and Preparedness in Integrating AI (PIA) exhibit a relatively high correlation (HTMT = 0.875), suggesting a substantial conceptual overlap between these constructs. Confidence in Learning AI (CLA) and Self-Transcendent Goal (STG) also demonstrate a high correlation (HTMT = 0.803), implying that motivation and confidence in AI learning may be closely linked. These findings suggest that while constructs are largely distinct, further refinement may be needed to ensure more precise differentiation between closely related variables (Henseler et al., 2015).

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distinct, further refinement may be needed to ensure more precise differentiation between closely related variables (Henseler et al., 2015).

The path analysis results reveal significant relationships between prior technology experience (PTE), attitude towards AI (ATA), and various AI-related constructs, indicating that foundational technological exposure has a strong influence on AI readiness, self-transcendent goals, and confidence in learning AI. The significant impact of PTE on AI readiness ($\beta = 0.257$, $p < 0.001$) aligns with studies emphasizing the importance of digital literacy in AI adoption (Zuo, Luo, Yan & Jiang, 2025). Additionally, the relationship between PTE and confidence in learning AI ($\beta = 0.273$, $p < 0.001$) supports findings that individuals with more prior technology experience exhibit greater confidence in handling AI tools (Wang et al., 2023). Attitude towards AI also has a substantial effect on AI readiness ($\beta = 0.504$, $p < 0.001$) and self-transcendent goals ($\beta = 0.361$, $p < 0.001$), reinforcing research that indicates positive perceptions of AI enhance both personal motivation and goal setting in AI learning (Huang & Rust, 2021). Furthermore, anxiety towards AI (AnAI) is significantly influenced by both PTE ($\beta = 0.217$, $p = 0.001$) and ATA ($\beta = 0.235$, $p < 0.001$), suggesting that while prior experience may help alleviate fears, attitudes towards AI remain a critical determinant of AI-related anxiety (Cantas, Soyer & Batur, 2024).

Constructs	**Items**	**FL**	**Cronbach**	**CR**	**AVE**
AI Readiness	AIR1	0.750	0.900	0.902	0.643
	AIR2	0.817			
	AIR3	0.828			
	AIR4	0.756			
	AIR5	0.855			
Attitude towards AI	ATA1	0.822	0.809	0.809	0.680
	ATA2	0.827			
Anxiety towards AI	AnAI1	0.939	0.842	0.864	0.741
	AnAI2	0.775			
Confidence in Learning AI	CLA1	0.797	0.828	0.827	0.614
	CLA2	0.741			
	CLA3	0.812			
Engagement in Learning AI	ELA1	0.843	0.918	0.918	0.736
	ELA2	0.866			
	ELA3	0.873			
	ELA4	0.851			
Preparedness in Integrating AI	PIA1	0.796	0.914	0.916	0.681
	PIA2	0.876			
	PIA3	0.753			
	PIA4	0.857			
	PIA5	0.839			
Prior Technology Experience	PTE1	0.721	0.694	0.694	0.531
	PTE2	0.736			
Self-Transcendent Goal	STG1	0.830	0.877	0.878	0.586
	STG2	0.757			
	STG3	0.727			
	STG4	0.711			
	STG5	0.796			

Note: FL = factor loadings; AVE = average variance extracted; α = Cronbach's alpha; CR = composite reliability; AIR = AI Readiness; ATA = Attitude towards AI; AnAI = Anxiety towards AI; CLA = Confidence in Learning AI; ELA = Engagement in Learning AI; PIA = Preparedness in Integrating AI; PTE = Prior Technology Experience; STG = Self-Transcendent Goal

Table 2. Measurement model assessment results

	AIR	ATA	AnAI	CLA	ELA	PIA	PTE	STG
AIR	0.802							
ATA	0.734	0.824						
AnAI	0.438	0.405	0.861					
CLA	0.758	0.573	0.352	0.784				
ELA	0.778	0.657	0.481	0.775	0.858			
PIA	0.738	0.620	0.357	0.754	0.876	0.825		
PTE	0.630	0.639	0.425	0.574	0.592	0.521	0.729	
STG	0.658	0.579	0.343	0.799	0.727	0.721	0.563	0.765

Table 3. Correlation matrices of constructs (Fornell & Larcker Criterion)

	AIR	ATA	AnAI	CLA	ELA	PIA	PTE	STG
AIR								
ATA	0.733							
AnAI	0.442	0.407						
CLA	0.758	0.572	0.354					
ELA	0.778	0.657	0.484	0.773				
PIA	0.737	0.620	0.358	0.751	0.875			
PTE	0.629	0.639	0.425	0.575	0.593	0.520		
STG	0.657	0.577	0.349	0.803	0.726	0.718	0.561	

Table 4. Heterotrait-monotrait (HTMT) ratio of correlation

Hypothesis	Path	Beta (β)	T values	p-values	Result
H1	PTE AnAI	0.217	3.381	0.001	Supported
H2	PTE AIR	0.257	4.705	0.000	Supported
H3	PTE STG	0.267	4.264	0.000	Supported
H4	PTE CLA	0.273	4.631	0.000	Supported
H5	ATA AnAI	0.235	3.764	0.000	Supported
H6	ATA AIR	0.504	9.521	0.000	Supported
H7	ATA STG	0.361	6.270	0.000	Supported
H8	ATA CLA	0.338	5.624	0.000	Supported
H9	ATA ELA	0.113	2.348	0.019	Supported
H10	AnAI ELA	0.138	3.614	0.000	Supported
H11	AIR ELA	0.301	4.852	0.000	Supported
H12	STG ELA	0.221	4.418	0.000	Supported
H13	CLA ELA	0.233	4.013	0.000	Supported
H14	ELA PIA	0.803	34.917	0.000	Supported

Note: AIR = AI Readiness; ATA = Attitude towards AI; AnAI = Anxiety towards AI; CLA = Confidence in Learning AI; ELA = Engagement in Learning AI; PIA = Preparedness in Integrating AI; PTE = Prior Technology Experience; STG = Self-Transcendent Goal

Table 5. Results of the Path Analysis

Moreover, engagement in learning AI (ELA) is significantly influenced by multiple factors, including AI readiness ($\beta = 0.301$, $p < 0.001$), confidence in learning AI ($\beta = 0.233$, $p < 0.001$), and self-transcendent goals ($\beta = 0.221$, $p < 0.001$). These findings are consistent with previous research, which highlights that individuals who perceive themselves as AI-ready and confident in learning AI exhibit higher engagement in AI-related activities (Ayanwale et al., 2025). Additionally, anxiety towards AI positively predicts engagement in learning AI ($\beta = 0.138$, $p < 0.001$), which aligns with the challenge-appraisal framework, suggesting that moderate levels of anxiety can serve as a motivator for active learning engagement (Lemay, Basnet & Doleck, 2020). The strong link between engagement in learning AI and preparedness for integrating AI (β = 0.803, $p < 0.001$) underscores the importance of fostering an engaging AI learning environment to ensure future AI integration readiness. These findings underscore the importance of well-structured AI education programs in fostering engagement and mitigating psychological barriers, such as anxiety (Huang & Rust, 2021).

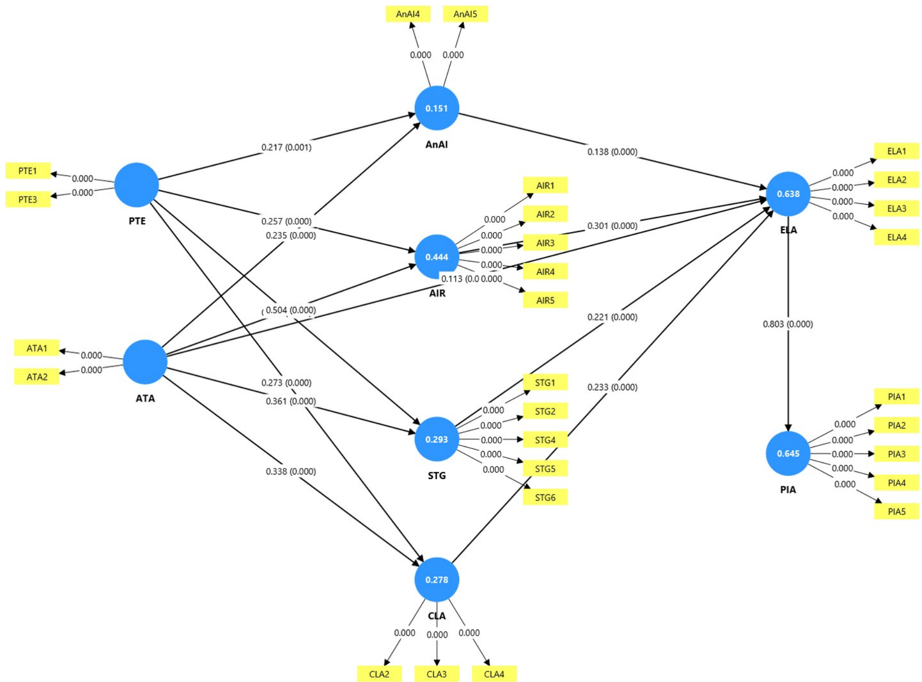

Figure 2. Final Model

4. Discussion

The implications of these findings suggest that individuals' readiness and preparedness for AI integration are well-captured by the measurement model, highlighting the importance of prior exposure and engagement in AI-related learning. The strong internal consistency of constructs such as AI Readiness and Engagement in Learning AI suggests that fostering positive attitudes and confidence in AI can enhance preparedness for its adoption (Ayanwale et al., 2025). Moreover, the high AVE for Anxiety towards AI suggests that fear or apprehension towards AI is a well-defined construct, warranting targeted interventions to reduce AI-related anxiety (Gunkel, 2024). The slightly lower reliability of prior technology experience suggests that additional dimensions, such as depth or duration of exposure, may need to be considered for future studies (Chin, Moeller, Johnson, Duwe, Graumlich, Murray et al., 2018). These results contribute to AI education and workforce training by highlighting the importance of confidence, engagement, and preparedness in adopting AI. Future research should investigate the longitudinal effects of AI readiness and interventions aimed at mitigating AI anxiety while enhancing engagement and preparedness (Dwivedi, Hughes, Ismagilova, Aarts, Coombs, Crick et al., 2021).

When compared to prior technology experience, attitude towards AI showed the most decisive influence on AI readiness among the relevant predictors. This indicates that students' preparedness is more influenced by their positive perceptions and openness to AI than by their actual technological experience (Abdo-Salloum & Al-Mousawi, 2025; Ofem, Orim, Edam-Agbor, Amanso, Eni, Ukatu et al., 2025). This further suggests that teachers should deliberately shape students' mindsets through reflective conversations, exposure to AI success stories, and the incorporation of real-world applications that explain AI technologies, as a complement to helping them build their technical skills (George, 2023). Similar to this, the moderate but considerable effect of prior technology experience highlights that, to develop readiness fully, technical knowledge should be combined with initiatives to promote confidence and curiosity about AI.

Furthermore, the strong correlation between engagement in learning AI and preparedness in integrating AI underscores that student involvement is the most significant link between learning and practical applications. This implies that to ensure students can translate AI literacy into real-world competence and adaptive skills in AI-driven environments, teaching pedagogies should prioritize experiential, gamified, and collaborative learning models that foster high engagement levels (Cantas et al., 2024).

The implications of these findings suggest that educational institutions and organizations should prioritize enhancing prior technology experience and fostering positive attitudes towards AI to improve AI readiness and confidence in learning. AI education programs should incorporate strategies to mitigate AI anxiety by offering hands-on learning experiences and highlighting the benefits of AI in various industries. Policymakers should also consider integrating AI literacy into digital education curricula to ensure a workforce that is both technically competent and psychologically prepared for the adoption of AI. Finally, future research could explore interventions aimed at reducing AI-related anxiety and increasing self-transcendent goals to enhance long-term engagement and AI preparedness. Ultimately, this study underscores the importance of a comprehensive AI learning framework that encompasses technical skills, psychological readiness, and engagement strategies for successful AI adoption.

5. Conclusions

The findings from the path analysis highlight the critical role of prior technology experience and attitudes towards AI in shaping AI readiness, confidence, and engagement in learning. The strong relationships between these factors suggest that individuals with more exposure to technology and a positive outlook on AI are better prepared to integrate AI into their professional and academic environments. Additionally, engagement in learning AI emerged as a significant predictor of preparedness for AI integration, reinforcing the need for immersive and interactive AI education. While AI anxiety was found to influence engagement, this relationship suggests that manageable levels of anxiety can serve as a motivator rather than a deterrent. The study highlights the importance of a comprehensive approach that combines technical skills, psychological readiness, and educational strategies to optimize AI adoption. Ultimately, fostering a supportive AI learning environment will be essential in equipping individuals with the skills and mindset needed to thrive in an AI-driven world.

However, this study is not without limitations. It primarily used a cross-sectional design, which limits the ability to infer causal correlations between constructs. Additionally, the sample was limited to preservice science teachers, which may limit the applicability of the results to other fields or work environments. Future studies should consider employing comparative or longitudinal approaches to monitor shifts in attitudes and preparedness for AI over time or in various educational contexts. A mixed-methods study could potentially yield a more profound understanding of how psychological and contextual elements impact AI preparedness and engagement.

Based on the study's findings, it is recommended that educational institutions integrate AI literacy programs into curricula to enhance students' prior technology experience and AI readiness. Training programs should focus on reducing AI anxiety by incorporating hands-on AI applications, real-world problem-solving activities, and AI-assisted learning tools. Additionally, educators should employ interactive teaching methods such as gamification and project-based learning to sustain engagement in AI education. Policymakers should advocate for AI awareness campaigns and workshops to improve attitudes towards AI and its ethical considerations. Future research should investigate the long-term effects of AI education interventions and explore the role of self-transcendent goals in promoting sustainable AI engagement. Lastly, organizations and industries should provide continuous AI upskilling programs to ensure their workforces are ready for AI integration and adoption.

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