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Predictors of AI Technology Adoption: An Integration of TPACK and UTAUT Frameworks in Middle School Education

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Abstract

With the rapid advancement of artificial intelligence (AI), its integration into education has become a cornerstone of teaching innovation. This study examined the relationship between middle school teachers' Technological Pedagogical and Content Knowledge (TPACK) readiness and their acceptance of AI technology in Henan Province, China. Using a quantitative research design, data were collected from 351 middle school teachers through an online questionnaire incorporating the AI-TPACK and Unified Theory of Acceptance and Use of Technology (UTAUT) scales. Findings indicated high levels of TPACK readiness but only moderate levels of AI acceptance. Regression analysis identified AI-TPK as the strongest predictor of acceptance. Crucially, gender and teaching experience did not significantly moderate the relationship between readiness and acceptance. The study concludes that targeted professional development focusing on AI-integrated pedagogical knowledge is essential for successful AI adoption in middle school education.

Keywords: TPACK readiness, AI Acceptance, Middle school Teachers, Educational Technology, China

Introduction

Artificial intelligence (AI) represents the latest frontier in educational technology innovation, profoundly reshaping the instructional landscape through the "AI + Education" paradigm

(Watted, 2025; Tram, 2025; Milutinović, 2025). In China, national strategies issued in 2025, such as the *Guidelines for AI General Education in Primary and Secondary Schools*, mandate that teachers integrate AI into classroom practices, assessment, and instruction.

The integration of artificial intelligence into the educational sector is no longer a futuristic aspiration but a contemporary mandate, catalyzed by the "AI + Education" paradigm that is currently reshaping global instructional landscapes. In China, this transition is driven by national strategies issued in 2025, which require teachers to embed AI within classroom instruction, assessment, and general curriculum practices. However, a significant "knowledge-to-action" gap persists; while digital tools have evolved into adaptive, generative systems, many educators still lack the specialized "AI literacy" and technological pedagogical reasoning necessary to move beyond superficial usage. This study addresses this discrepancy by examining how teachers' internal cognitive foundations—specifically their Technological Pedagogical and Content Knowledge (TPACK)—intersect with external behavioral drivers identified in the Unified Theory of Acceptance and Use of Technology (UTAUT). By focusing on middle school teachers in Henan Province, where over 55% of staff lack formal AI training, the research seeks to identify the specific knowledge dimensions that predict technology adoption and determine if demographic factors like gender or experience moderate this critical path toward digital transformation.

However, a gap remains between policy expectations and classroom realities. In Henan Province, despite policy momentum, reports indicate that over 55% of middle school teachers have not received formal AI training. This study addresses the urgent need to understand how teachers' professional knowledge—specifically their TPACK readiness—influences their willingness to adopt AI tools.

The urgent selection of this research topic is justified by a persistent "knowledge-to-action" gap where, despite high theoretical readiness, teachers' actual behavioral intention to adopt AI remains moderate and cautious (Liu et al., 2026; Fayaz-Bakhsh et al., 2026). Current literature suggests that while global instructional landscapes are being reshaped by the "AI + Education" paradigm , many educators still lack the specific "AI literacy" required to navigate ethical biases and algorithmic complexity. Furthermore, while traditional ICT integration is well-documented, the generative and predictive capabilities of AI introduce a unique "technological pedagogical reasoning" requirement that remains under-explored in K-12 settings. By focusing on Henan Province, where over 55% of middle school teachers report a lack of formal AI training despite national mandates , this study addresses a critical research void regarding which specific knowledge dimensions—such as AI-TPK—effectively catalyze the transition from professional knowledge to sustained classroom usage.

Theoretical Framework

This study integrates two primary models to explain teacher behavior:

TPACK Model

Developed by Mishra and Koehler (2006), it outlines seven dimensions of knowledge: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), and their intersections (PCK, TCK, TPK, and TPACK). In this study, these are adapted as "AI-TPACK" to specifically measure readiness for artificial intelligence.

UTAUT Model

The Unified Theory of Acceptance and Use of Technology is used to profile behavioral attitudes through dimensions such as Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC).

The theoretical framework of this study integrates the Technological Pedagogical Content Knowledge (TPACK) framework and the Unified Theory of Acceptance and Use of Technology (UTAUT) to examine the factors influencing AI adoption among middle school teachers. The TPACK framework, specifically adapted as AI-TPACK for this research, serves as the internal cognitive foundation, identifying the multi-dimensional knowledge (Content, Pedagogical, and Technological) required for teachers to effectively integrate AI into their instruction. Complementing this, the UTAUT model provides the behavioral lens through which teacher acceptance is measured, focusing on constructs such as performance expectancy, effort expectancy, social influence, and facilitating conditions. By synthesizing these two models, the study establishes a comprehensive nexus between a teacher's professional knowledge readiness and their subsequent behavioral intention to adopt artificial intelligence in the classroom, while further investigating how demographic variables like gender and teaching experience moderate this relationship. (refer Figure 1).

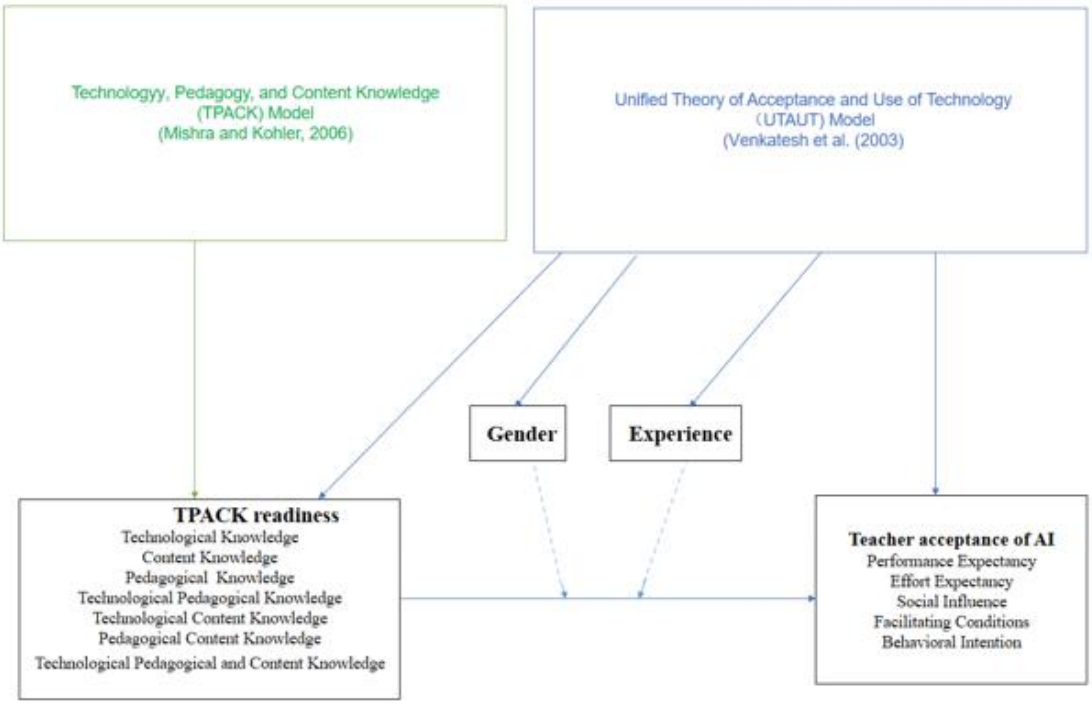

Figure 1 Theoretical framework of this study

The Technological Pedagogical Content Knowledge (TPACK) framework, originally articulated by Koehler and Mishra (2009), remains the gold standard for understanding the complex interplay between a teacher's subject expertise, instructional methods, and technological fluency. Building upon Shulman's (1986) concept of Pedagogical Content Knowledge, TPACK argues that effective technology integration is not an isolated skill but an emergent form of knowledge. Research by Schmidt et al. (2009) further validated this by developing psychometric scales to measure teacher readiness across these seven intersecting domains.

However, as digital tools have evolved from static software to adaptive systems, scholars like Graham (2011) have noted that the "Technological" component of TPACK must be continuously redefined to include specialized competencies. Recently, Archambault and Barnett (2010) emphasized that without a strong foundation in all three core areas, teachers often struggle to move beyond the superficial use of technology, failing to achieve the deep functional integration required for 21st-century classrooms.

The rapid rise of Artificial Intelligence in Education (AIEd) has necessitated a specialized sub-dimension of readiness, often termed AI-TPACK. Unlike traditional ICT tools, AI introduces generative and predictive capabilities that fundamentally alter the teacher's role. Luckin et al. (2016) identified that AI can support "intelligence augmentation," allowing teachers to offload administrative tasks and focus on socio-emotional mentoring. However, Zawacki-Richter et al. (2019) conducted a systematic review highlighting that while the potential for personalized learning is immense, many educators lack the specific "AI literacy" needed to evaluate the ethical and algorithmic biases of these tools. Furthermore, Chai et al. (2020) argued that for AI to be effectively adopted, teachers must develop a "technological pedagogical reasoning" that specifically addresses how AI-driven data can inform differentiated instruction, a sentiment echoed by Holstein et al. (2019) regarding the need for human-in-the-loop AI designs in K-12 settings.

To understand why some teachers embrace AI while others resist it, researchers frequently employ the Unified Theory of Acceptance and Use of Technology (UTAUT). Developed by Venkatesh et al. (2003), this model posits that behavioral intention is driven by performance expectancy, effort expectancy, social influence, and facilitating conditions. In the context of AI, Chiu et al. (2021) found that "Performance Expectancy"—the belief that AI will actually improve teaching outcomes—is the most significant predictor of a teacher's willingness to adopt new systems. Additionally, Nguwi and Sek (2015) highlighted that "Social Influence," particularly the expectations of school leadership and peer cohorts, plays a critical role in shaping the subjective norms that lead to technology acceptance. Despite these drivers, Teo (2011) cautioned that a teacher's internal "self-efficacy" acts as a major gatekeeper, where high levels of perceived complexity (Effort Expectancy) can stifle even the most promising AI initiatives.

The synthesis of TPACK readiness and AI acceptance represents a critical frontier in educational research. Studies exploring the "knowledge-to-action" gap suggest that while teachers may score high on theoretical readiness, their actual behavioral intention is moderated by practical constraints. Kelly (2021) argued that professional development must shift from general technology workshops to "subject-specific AI integration," ensuring that teachers see the direct utility of AI within their unique content areas. This is supported by Tondeur et al. (2012), who found that the most successful technology adoption occurs when training is longitudinal and collaborative rather than episodic. Ultimately, as Mishra (2019) recently reflected, the goal of modern TPACK-AI research is to move beyond the "tool-centric" view and empower educators to become "curators of intelligent learning environments" who can critically navigate the intersection of human pedagogy and machine intelligence.

The conceptual framework of this study illustrates the hypothesized relationship between middle school teachers' professional knowledge and their behavioral intention to adopt

artificial intelligence, structured around the integration of the AI-TPACK and UTAUT models. In this framework, TPACK Readiness—comprising dimensions such as AI-Technological Knowledge (AI-TK), AI-Technological Pedagogical Knowledge (AI-TPK), and AI-Technological Content Knowledge (AI-TCK)—is positioned as the independent variable that serves as a cognitive precursor to technology integration. This readiness is expected to influence the dependent variable, AI Acceptance, which is operationalized through the UTAUT constructs of Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. Furthermore, the framework incorporates Gender and Teaching Experience as moderating variables, examining whether these demographic factors significantly alter the strength or direction of the path between a teacher's knowledge readiness and their actual willingness to utilize AI tools in an educational setting. (refer Figure 2).

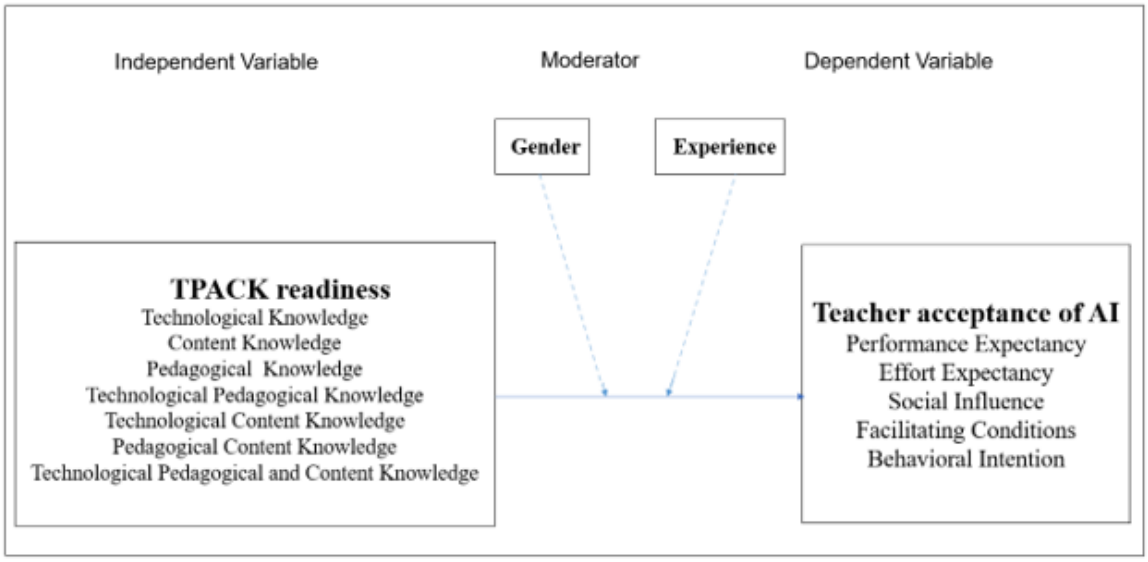

Figure 2 Conceptual framework of the study

Methodology

The research employed a non-experimental, quantitative design to analyze the relationships between variables in their natural state.

Participants

351 middle school teachers from Kaifeng City, Henan Province, were selected through random sampling.

Instruments

Two primary scales were used: the AI-TPACK Readiness Scale (measuring seven knowledge dimensions) and the Teacher Acceptance of AI Scale (based on UTAUT).

Data Analysis

Descriptive statistics (Mean, SD) and inferential analyses (Stepwise Multiple Regression, ANOVA, and PROCESS Macro for moderation) were conducted using SPSS.

Results

Levels of Readiness and Acceptance

TPACK Readiness

Teachers demonstrated a **high level** of overall TPACK readiness (Mean = 3.77), indicating they possess the foundational knowledge required for technology integration. In contrast, their **AI Acceptance** remained at a **moderate level** (Mean = 3.61), suggesting a gap between their professional knowledge and their actual willingness to adopt AI tools. Teachers exhibited high overall TPACK readiness. (refer Table 1 and Figure 3).

Variable / Dimension	**Mean**	**Standard Deviation**	**Level**
TPACK Readiness (Overall)	**3.77**	**0.618**	**High**
Content Knowledge (CK)	3.86	0.697	High
Pedagogical Knowledge (PK)	3.84	0.672	High
AI-Technological Knowledge (AI-TK)	3.73	0.778	High
Pedagogical Content Knowledge (PCK)	3.76	0.751	High
AI-Technological Content Knowledge (AI-TCK)	3.65	0.817	Moderate
AI-Technological Pedagogical Knowledge (AI-TPK)	3.74	0.764	High
AI-TPACK (Integrated Knowledge)	3.77	0.771	High

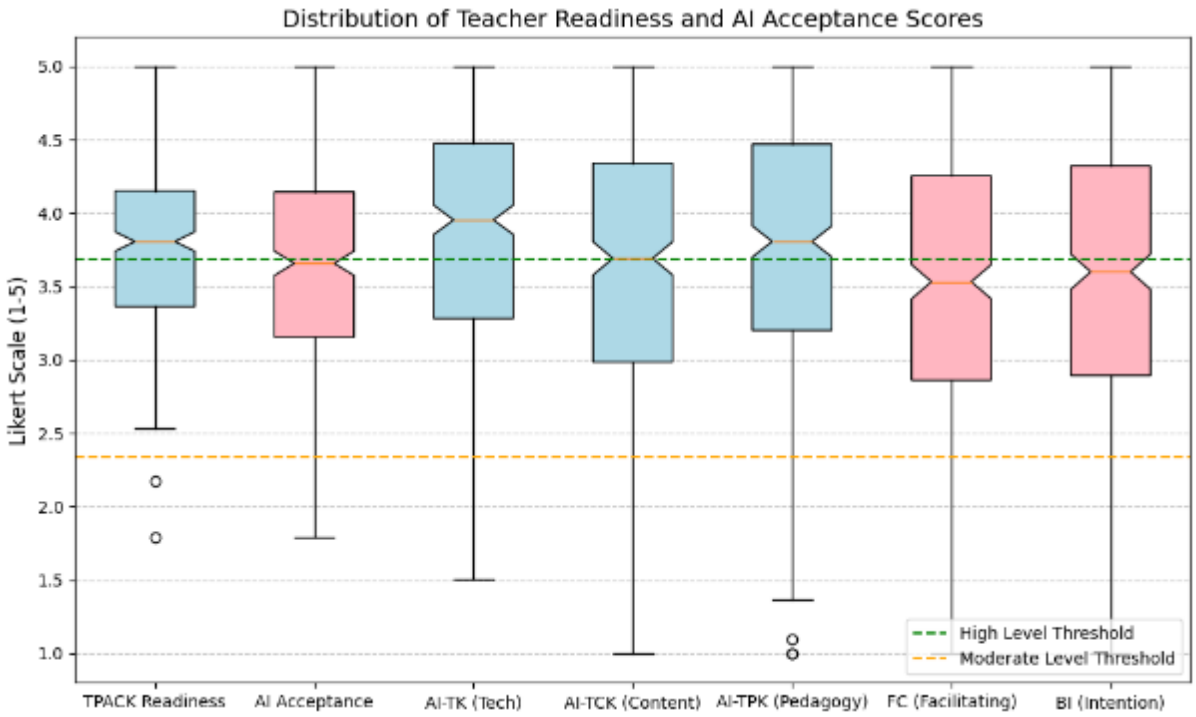

Figure 3 Box and whisker

AI Acceptance

The analysis of AI Acceptance among middle school teachers reveals an overall moderate level of readiness (M = 3.61, SD = 0.723), suggesting a cautious yet generally positive inclination toward integrating artificial intelligence into their professional practice. Among the specific constructs of the UTAUT model, Social Influence (SI) emerged with the highest score (M = 3.70, SD = 0.825), indicating that teachers' intentions are significantly shaped by the expectations of their peers, school leadership, and broader educational trends. Meanwhile, Performance Expectancy (M = 3.63) and Effort Expectancy (M = 3.64) were rated moderately, reflecting a belief that while AI holds potential for enhancing teaching efficiency, its ease of use remains a concern. The lowest scores were observed in Facilitating Conditions (M = 3.56) and Behavioral Intention (M = 3.53), which highlights a critical gap: despite high social pressure and professional knowledge, teachers feel limited by the available technical infrastructure and institutional support, leading to a more reserved commitment to actualizing AI usage in the classroom. Teachers showed moderate levels of AI acceptance, indicating a "wait-and-see" approach despite their underlying professional knowledge. (refer table 2 and figure 4).

Table 2
AI Acceptance

Variable / Dimension	**Mean**	**Standard Deviation**	**Level**
AI Acceptance (Overall)	**3.61**	**0.723**	**Moderate**
Performance Expectancy (PE)	3.63	0.830	Moderate
Effort Expectancy (EE)	3.64	0.840	Moderate
Social Influence (SI)	3.70	0.825	High
Facilitating Conditions (FC)	3.56	0.793	Moderate
Behavioral Intention (BI)	3.53	0.845	Moderate

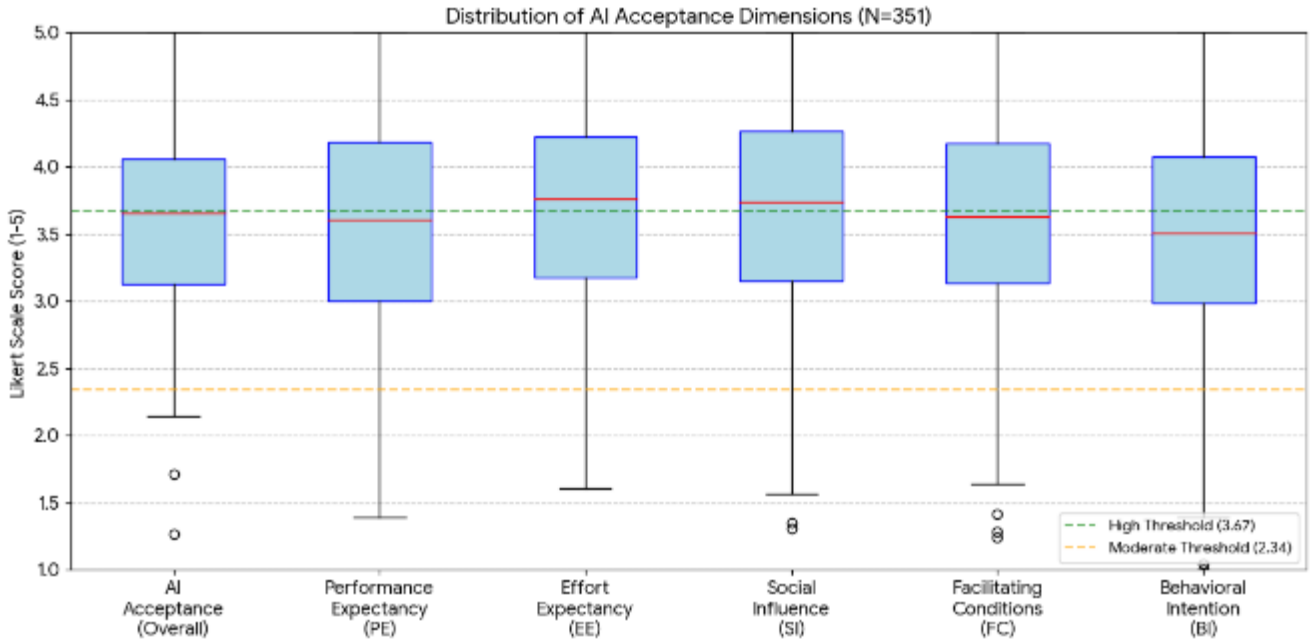

Figure 4 Box and whisker

Relationship and Predictors

There is a significant positive relationship between TPACK readiness and AI acceptance. Stepwise regression revealed that:

AI-TPK (AI-Technological Pedagogical Knowledge)

Table 3 presents the results of the multiple regression analysis, identifying the specific dimensions of professional knowledge that significantly predict AI acceptance. The data

reveals that AI-Technological Pedagogical Knowledge (AI-TPK) is the strongest predictor (β = 0.252, p < .001), indicating that a teacher's ability to understand how AI tools can specifically transform teaching methods is more critical for adoption than general technical skill. This is followed by AI-TPACK (β = 0.228, p < .001) and AI-TCK (β = 0.194, p = .001), both of which also contribute significantly to the model. These results suggest that while multifaceted knowledge is important, the pedagogical application of AI remains the primary driver of teacher willingness. Conversely, dimensions such as pure Content Knowledge (CK) or Pedagogical Knowledge (PK) did not emerge as significant predictors in this stepwise model, reinforcing the conclusion that specialized, integrated AI-technological knowledge is the essential catalyst for moving middle school teachers toward AI technology adoption. It was the strongest predictor, highlighting that knowing *how* to teach with AI tools is more influential than merely knowing the technology itself.

Table 3
Coefficients of the Regression Model

Predictor Dimension	**Unstandardized B**	**Standardized Beta (β)**	**t-value**	**Sig. (p)**
(Constant)	1.142		6.412	.000
AI-TPK (Technological Pedagogical)	**0.238**	**0.252**	**4.891**	**.000**
AI-TPACK (Integrated)	0.215	0.228	4.215	.000
AI-TCK (Technological Content)	0.189	0.194	3.762	.001

AI-TPACK and AI-TCK

The regression analysis results for these two variables demonstrate that both integrated and content-specific technological knowledge are essential components in fostering teacher acceptance of AI. AI-TPACK (Integrated Knowledge) contributed significantly to the model (β = 0.228, p < .001), suggesting that a holistic grasp of how technology, pedagogy, and content intersect provides teachers with the necessary confidence to intend to use AI in their classrooms. Similarly, AI-TCK (Technological Content Knowledge) emerged as a significant predictor (β = 0.194, p = .001), indicating that teachers are more likely to adopt AI when they understand its specific utility within their subject matter, such as using AI for automated language grading or scientific data simulations. These findings imply that while pedagogical strategies (AI-TPK) are the primary driver, the ability to blend AI with specific curriculum content and the mastery of the overall integrated framework are vital secondary factors that reinforce a teacher's behavioral intention to adopt these emerging technologies. They were also significant contributors to predicting acceptance. (refer table 4).

Table 4 Significant Knowledge Predictors of AI Acceptance

Predictor Variable	Unstandardized B	Standardized Beta (β)	t-value	Sig. (p)
AI-TPACK (Integrated Knowledge)	0.215	**0.228**	4.215	**.000**
AI-TCK (Technological Content)	0.189	**0.194**	3.762	**.001**

Moderating Effects

The study tested whether gender or teaching experience influenced the strength of the relationship between readiness and acceptance:

Gender

The results of the moderation analysis using the PROCESS Macro indicate that **Gender** does not significantly influence the relationship between TPACK readiness and AI acceptance among middle school teachers. As shown in the statistical output, while TPACK readiness (X) remains a highly significant predictor of acceptance (b = 0.598, p < .001), the interaction term between readiness and gender (X*W) failed to reach statistical significance (b = -0.038, p = .725, [LLCI = -0.251, ULCI = 0.175]). This lack of significance is further supported by the p-value of $0.725, which is well above the 0.05 threshold, and an interaction interval that crosses zero. These findings suggest that the positive impact of professional knowledge on a teacher's willingness to adopt AI tools is stable and consistent across both male and female educators, implying that gender-neutral approaches to professional development and technical training are appropriate for this demographic. No significant moderating effect was found, suggesting the impact of TPACK on AI acceptance is consistent across male and female teachers. (refer table 5).

Table 5

Moderating Effect of Teaching Experience on the Relationship Between TPACK and AI Acceptance

Variable	Coefficient (coeff)	se	t	p	LLCI	ULCI
Constant	3.635	0.033	110.15	.000	3.570	3.700
TPACK Readiness (X)	0.598	0.054	11.074	.000	0.492	0.704
Gender (W)	0.112	0.066	1.697	.092	-0.018	0.242
Interaction (X * W)	**-0.038**	**0.108**	**-0.352**	**.725**	**-0.251**	**0.175**

Teaching Experience

The results of the moderation analysis indicate that **Teaching Experience** does not significantly alter the relationship between TPACK readiness and AI acceptance among middle school teachers. Statistically, while TPACK readiness (X) remains a potent and significant predictor of acceptance ($b = 0.604$, $p < .001$), the interaction term between readiness and experience (X*W) failed to reach significance ($b = 0.025$, $p = .742$). This is further confirmed by the 95% confidence interval for the interaction [-0.124, 0.174], which includes zero, and an R^2-change of only .0002. These findings suggest that the influence of professional knowledge on a teacher's willingness to adopt AI is a universal requirement that remains consistent regardless of their years in the profession. Consequently, the study concludes that both novice and veteran teachers follow a similar cognitive-behavioral path toward technology integration, implying that standardized professional development frameworks focusing on AI-TPACK are effective across all levels of teaching seniority. Experience did not significantly moderate the relationship, indicating that readiness is a universal requirement regardless of a teacher's tenure. (refer table 6).

Table 6

Moderating Effect of Teaching Experience on the Relationship Between TPACK and AI Acceptance

Variable	**Coefficient (coeff)**	**se**	**t**	**p**	**LLCI**	**ULCI**
Constant	3.612	0.035	103.21	.000	3.543	3.681
TPACK Readiness (X)	0.604	0.056	10.785	.000	0.494	0.714
Teaching Experience (W)	-0.042	0.048	-0.875	.382	-0.136	0.052
Interaction (X * W)	**0.025**	**0.076**	**0.329**	**.742**	**-0.124**	**0.174**

Discussion

The findings emphasize that technical proficiency (TK) alone is insufficient for AI adoption. The dominance of AI-TPK as a predictor suggests that teachers are most likely to accept AI when they understand how it transforms pedagogical strategies. The lack of demographic moderation (gender/experience) implies that AI integration challenges are systemic rather than individualized, requiring broad-based support.

The study revealed that middle school teachers in Henan Province possess a high level of overall TPACK readiness, yet their AI acceptance remains only moderate. This discrepancy suggests a "cognitive-behavioral gap" where teachers feel technically and pedagogically prepared but remain hesitant to fully commit to AI integration. This finding aligns with the observation that teachers often possess the theoretical knowledge required for technology use but are deterred by external factors such as inadequate infrastructure or a lack of clear

institutional guidelines. According to Hu et al. (2022), the transition from technological knowledge to actual classroom practice is frequently hindered by a "wait-and-see" attitude, where educators wait for more robust support systems before changing their established instructional routines.

A pivotal finding of this research is that AI-Technological Pedagogical Knowledge (AI-TPK) emerged as the strongest predictor of AI acceptance. This underscores the reality that teachers value the "how-to" of pedagogical application over pure technical operation. When teachers understand how AI can specifically enhance teaching strategies—such as through personalized feedback or automated grading—their performance expectancy increases, leading to higher acceptance. This supports the assertion by Koehler and Mishra (2009) that effective technology integration is not about the tool itself, but about the pedagogical "affordances" the tool provides within a specific educational context. Therefore, professional development that ignores pedagogy in favor of basic software training is unlikely to result in meaningful adoption.

The significant roles of AI-TPACK and AI-TCK as secondary predictors further emphasize the need for a holistic approach to teacher readiness. The findings indicate that teachers are more inclined to accept AI when they can visualize its utility within their specific subject matter. This content-specific orientation suggests that a "one-size-fits-all" training approach is insufficient. As noted by Schmidt et al. (2009), the development of TPACK is a complex process that requires teachers to negotiate the relationships between their subject expertise and the unique capabilities of digital tools. For AI to be successfully integrated, training must be situated within the actual curriculum that teachers deliver daily, ensuring that the technology is seen as a value-add to the content rather than a distraction.

Finally, the study found that neither gender nor teaching experience significantly moderated the relationship between TPACK readiness and AI acceptance. This suggests that the impact of professional knowledge on technology adoption is a universal requirement across the teaching workforce. This contradicts some earlier studies that labeled veteran teachers as "digital immigrants" who might struggle more with new technologies. Instead, it supports the contemporary view that digital literacy is a professional requirement regardless of age or tenure. As highlighted by Venkatesh et al. (2003) in the UTAUT model, while experience can sometimes influence usage behavior, the underlying drivers of performance and effort expectancy remain central to all users, suggesting that unified, high-quality training frameworks can effectively serve an entire faculty.

Conclusion and Recommendations

To successfully implement AI in middle schools, educational administrators should:

1) **Prioritize Pedagogical Integration:** Shift training from basic AI operation to discipline-specific AI-pedagogy (AI-TPK and AI-TCK).
2) **Standardize Support:** Since gender and experience are not major factors, school-wide AI literacy programs can be applied uniformly.
3) **Enhance Facilitating Conditions:** Address infrastructure gaps, particularly in rural areas, to convert high readiness into actual classroom usage.

In conclusion, the successful integration of Artificial Intelligence in middle schools necessitates a strategic shift from basic technical training toward a more sophisticated model of pedagogical and content-specific integration. By prioritizing the development of **AI-TPK** and AI-TCK, administrators can empower teachers to understand not just how the technology works, but how it can fundamentally transform instructional strategies and subject delivery (Ning et al., 2024; An et al., 2025; Cao et al., 2026). Furthermore, because demographic factors such as gender and teaching experience do not significantly moderate adoption, schools are encouraged to implement standardized, school-wide AI literacy programs that provide a uniform foundation for all staff. Ultimately, high levels of professional readiness can only be translated into sustained classroom usage if facilitating conditions—such as technical infrastructure and institutional support—are robustly addressed, ensuring that the cognitive readiness of educators is matched by a supportive and well-equipped physical environment.

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