

A Study on the Influence Mechanism of Rural English Teachers' AI Teaching Self-Efficacy from the Perspective of TPACK Theory

Ziying Ling

School of Foreign Studies, South China Normal University, Guangzhou, China.
Email: 20230221081@m.scnu.edu.cn

Anqi Wen

School of Foreign Studies, South China Normal University, Guangzhou, China.
Email: 202402211654@m.scnu.edu.cn

Xinyun Li

School of Foreign Studies, South China Normal University, Guangzhou, China.
Email: 20231332018@m.scnu.edu.cn

Yujian Huang

School of Foreign Studies, South China Normal University, Guangzhou, China.
Email: 20230221162@m.scnu.edu.cn

Yongyi Mo*

School of Foreign Studies, South China Normal University, Guangzhou, China.
Email: moyongyi@m.scnu.edu.cn

Recibido / Received: 22/01/2026
Aceptado / Accepted: 28/06/2026

Abstract: While Artificial Intelligence (AI) is rapidly penetrating education, the mechanisms translating teachers' technological competence into pedagogical confidence remain opaque, particularly in resource-constrained rural contexts. Grounded in the TPACK framework, this mixed-methods study investigates the predictive mechanisms governing AI teaching self-efficacy among 115 rural English educators in western Guangdong. Quantitative analyses reveal an "upper-middle" but fundamentally uneven developmental profile: teachers demonstrate solid foundational knowledge yet acute deficiencies in high-order technology integration. Consequently, their basic AI comprehension significantly outpaces their confidence in orchestrating complex pedagogical tasks, such as AI-assisted assessment. Crucially, linear regression demonstrates that holistic TPACK capabilities significantly predict AI teaching self-efficacy, explaining 41.2% of the variance. Triangulated interview data attribute these bottlenecks to isolated practice environments and obsolete pedagogical conceptualizations rather than mere technical anxiety. By delineating AI teaching self-efficacy from general tool proficiency, this study provides vital empirical evidence advocating for pedagogy-driven interventions to achieve equitable digital transformation.

Keywords: TPACK Theory, Artificial Intelligence, Rural English Teachers, AI Teaching Self-Efficacy, Influence Mechanism.

1. Introduction

As artificial intelligence becomes the core driving force of a new round of scientific and technological revolution (Wu & Bai, 2025), its penetration into the field of English education is particularly critical, making the ability to integrate AI with English teaching an essential competency for English teachers. Celik (2023), building upon the TPACK

theoretical framework proposed by Mishra and Koehler (2006), constructed a five-dimensional Intelligent-TPACK (i.e., AI-TPACK) theoretical system by adding specific dimensions focusing on AI characteristics (Intelligent Technological Knowledge, Intelligent Technological Content Knowledge, Intelligent Technological Pedagogical Knowledge, and Intelligent Technological Pedagogical Content Knowledge) alongside an ethical evaluation dimension (covering transparency, inclusivity, fairness, and accountability). This systematically embeds AI knowledge and ethical considerations into the professional development path of teachers. Furthermore, Mishra, Warr and Islam (2023) conducted research on the challenges and restructuring that generative AI brings to the traditional TPACK framework, providing an authoritative guide and deepening the theoretical foundation of AI-TPACK. Together, they have driven the integration of the fourfold requirements of technology, pedagogy, content, and ethics in AI education integration scenarios (Celik, 2023; Mishra & Koehler, 2006; Mishra et al., 2023).

Kim et al. (2021) analyzed K-12 AI teaching materials using the TPACK framework and found that teachers must possess comprehensive three-dimensional knowledge of technology, pedagogy, and content to effectively conduct AI project-based learning. Multiple surveys show that teachers' competency levels across the various dimensions of AI-TPACK are generally low; in particular, there is a lack of systematic training in AI-TK and ethical cognition. Digital proficiency has a significant positive predictive effect on AI-TPACK, making the enhancement of digital skills a critical pathway to improving AI-TPACK (Hava & Babayigit, 2024). Cheng et al. (2024) proposed a teacher training strategy under a blended learning environment based on the AI-TPACK theory and verified the training's effectiveness through experimental research on pre-service teachers.

There is a significant intergenerational difference in the AI literacy levels of rural teachers. Older teachers exhibit particularly weak performance in the deep integration of technology and teaching content due to their low technological acceptance and insufficient willingness for digital learning (Xie & Wang, 2024). Targeted AI training needs to design layered content based on the TPACK framework and focus on enhancing teachers' Technological Integration Knowledge (TIK) through a model of "normalized learning on online platforms + centralized reinforcement in offline practice," thereby strengthening their AI teaching self-efficacy (Zhao & Yang, 2025).

Despite the robust theoretical development of the AI-TPACK framework (Celik, 2023; Mishra et al., 2023), a critical void remains in understanding the cognitive and psychological mechanisms that govern teachers' transition from traditional technological competence to advanced AI pedagogical execution. Specifically, aligned with our third research question (RQ3), it remains fundamentally unknown which specific dimension of TPACK plays the core predictive role in this process. While established dimensions were conceptualized for static multimedia tools, it is vital to identify whether foundational knowledge (CK, PK) or higher-order intersectional integration (TCK, TPK) acts as the primary catalyst for the highly dynamic construct of AI teaching self-efficacy in under-resourced environments. Addressing this mechanism is of paramount importance. As generative artificial intelligence reshapes the educational landscape, the digital divide in rural education is rapidly mutating from an infrastructure deficit to a "pedagogical capacity" deficit. Rural English teachers, who are uniquely positioned to benefit from AI tools for standardized pronunciation and personalized tutoring, are instead caught in a paralyzing cycle of "insufficient AI literacy leading to low teaching self-efficacy". If the specific TPACK dimensions that catalyze AI teaching confidence

are not identified, subsequent professional development initiatives remains misaligned, exacerbating educational inequities rather than resolving them.

This study uniquely addresses this theoretical and practical impasse by adopting a mixed-methods design to investigate 115 in-service rural English teachers in western Guangdong—a demographic characterized by distinct intergenerational technological barriers and resource limitations. By systematically testing the predictive effect of holistic TPACK capabilities on the multidimensional construct of AI teaching self-efficacy, and triangulating these quantitative models with deep qualitative interview insights, this research pioneers empirical evidence on the boundary conditions of TPACK. Ultimately, it provides a highly targeted, evidence-based blueprint for innovating rural teacher training models and breaking through the bottlenecks of deeply integrated AI application.

2. Literature Review

2.1. The Connotation and Development of the TPACK Theoretical Framework

The TPACK (Technological Pedagogical Content Knowledge) theory was proposed by Mishra and Koehler (2006). Its core requirement is that teachers simultaneously master three core knowledge dimensions and, through the cross-integration of these dimensions, form three derivative knowledge dimensions. The six dimensions support each other and intertwine layer by layer to ultimately form the core TPACK composite capability. The three core knowledge dimensions are Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK); under the intersection of the three core dimensions, three intersecting knowledge dimensions are further formed: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Pedagogical Content Knowledge (PCK). The deep integration of all dimensions ultimately constitutes the TPACK composite capability located at the core of the framework.

Initially conceptualized for static multimedia tools, TPACK posits that effective technology integration requires the synchronous mastery and deep cross-pollination of three core knowledge bases: Technology (TK), Pedagogy (PK), and Content (CK). The dynamic intersection of these foundational bases generates specialized derivative dimensions—Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Pedagogical Content Knowledge (PCK). Rather than treating technology as an isolated operational skill, the TPACK framework dictates that genuine educational innovation occurs exclusively at the nexus of all elements, where technology serves as a transparent conduit for pedagogical design and subject matter representation. In the contemporary context of educational informatization, robust TPACK capabilities serve as a critical indicator for evaluating a teacher's digital integration proficiency. It provides a systematic instructional design mechanism, facilitating teachers' transition from basic technology users to proactive orchestrators of student-centered learning contexts (Komarudin & Suherman, 2024; Rakes et al., 2022).

As a systematic framework of teaching knowledge, TPACK possesses multiple core values in the context of informatized education: It provides a clear instructional design framework for teachers, helping them consciously integrate technology, pedagogy, and subject content in teaching practice, thereby realizing technology-

driven teaching innovation (Komarudin & Suherman, 2024). It has become an important indicator for measuring teachers' digital literacy, effectively promoting teachers' mastery and flexible use of Information and Communication Technology (ICT) resources to improve classroom teaching quality (Li, Liu & Su, 2022). Through the deep integration of technology and content, it helps to construct student-centered learning contexts, enhancing students' concept comprehension, problem-solving, and innovation abilities (Komarudin & Suherman, 2024). Simultaneously, it clarifies teachers' knowledge needs in technology, pedagogy, and content, providing a scientific basis for teacher training, curriculum design, and teaching evaluation (Zhang & Tang, 2021). Furthermore, the enhancement of TPACK literacy can significantly improve teachers' technological self-efficacy, helping teachers establish teaching confidence in an informatized teaching environment (Resbiantoro, 2017).

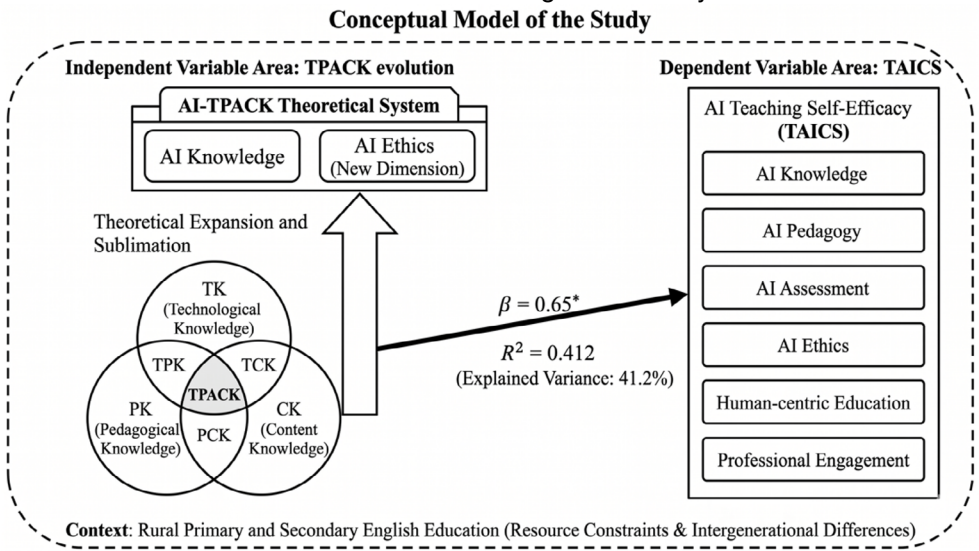
2.2. AI-TPACK Theoretical System

With the deep penetration of artificial intelligence in the educational field, the traditional TPACK theory is no longer sufficient to meet the specialized needs of AI teaching scenarios, and the academic community has begun to expand it contextually and perfect it systematically, forming the AI-TPACK theoretical system. The construction of this theoretical system is based on the core of the TPACK framework. Core promoter Celik (2023), building upon the TPACK theoretical framework proposed by Mishra and Koehler (2006), constructed a five-dimensional Intelligent-TPACK (i.e., AI-TPACK) theoretical system by adding specific dimensions focusing on AI characteristics (Intelligent-TK, Intelligent-TCK, Intelligent-TPK, Intelligent-TPACK) and an ethical evaluation dimension (covering transparency, inclusivity, fairness, and accountability), systematically embedding AI knowledge and ethical considerations into teachers' professional development paths. Meanwhile, TPACK theory co-founder Mishra et al. (2023) launched specialized research on the challenges and restructuring of the traditional TPACK framework by generative AI, providing authoritative guidance and deepening for the theoretical foundation of AI-TPACK. Together, the two promoted the deep integration of the fourfold requirements of technology, pedagogy, content, and ethics in AI education integration scenarios (Celik, 2023; Mishra & Koehler, 2006; Mishra et al., 2023).

Structurally, AI-TPACK forms a five-layer pyramid model consisting of "Intelligent-TK, Intelligent-TCK, Intelligent-TPK, Intelligent-TPACK, and Ethics". Compared to traditional TPACK, its core innovation lies in adding the rigid requirements of the ethical dimension while systematically embedding AI-specific knowledge dimensions, making the theoretical framework more suitable for the special needs of artificial intelligence educational scenarios. The theoretical core of AI-TPACK still continues the core integration logic of "technology-pedagogy-content" of TPACK, where the literacy of various dimensions of TPACK is the foundation and prerequisite for teachers to form AI-TPACK capability, and the formation of AI-TPACK capability directly affects a teacher's self-efficacy in AI teaching scenarios (Celik, 2023). Existing research has verified the enhancing effect of AI-TPACK theory-based training on teachers' AI teaching capabilities (Cheng et al., 2024). However, its implementation is highly context-dependent, revealing distinct contradictions between foreign and domestic research conclusions. While recent foreign empirical studies emphasize fundamental infrastructural deficits—such as Castro et al. (2025) and Elifas and Simuja (2024)

highlighting a lack of offline-capable resources and hardware in rural schools—the primary barrier in domestic contexts is often demographic. In the specific scenario of rural western Guangdong, AI integration is distinctly hindered by regional resource disparities and an aging teaching workforce. The core challenge here is less about sheer hardware absence and more about an intergenerational “pedagogical capacity” deficit among senior teachers facing emerging technologies. Given these systemic constraints, there is still a clear research gap regarding the transmission mechanism of how traditional TPACK dimensions lay the foundation for AI-TPACK capabilities and subsequently affect AI teaching self-efficacy, especially concerning empirical testing on the group of rural English teachers. This study focuses on a TPACK scale survey to explore its impact on the AI teaching self-efficacy of rural English teachers, aiming to lay a foundation for subsequent empirical research on AI-TPACK and the design of specialized training for rural teachers.

Figure 1: The Conceptual Model of this Study, Demonstrating how Traditional TPACK Dimensions Evolve into AI-TPACK and Predict the Multi-dimensional Construct of AI Teaching Self-efficacy.



2.3. Self-Efficacy and Teachers' AI Teaching Self-Efficacy

In contemporary educational technology research, it is imperative to distinguish between general AI self-efficacy and AI teaching self-efficacy (TAICS). While general AI self-efficacy denotes a user's perceived operational competence in interacting with artificial intelligence tools, AI teaching self-efficacy is a highly specialized, context-dependent pedagogical construct. It defines an educator's belief in their capability to orchestrate AI technologies within complex classroom environments, align them with specific pedagogical goals, and manage the resultant student dynamics and ethical considerations (Chiu, Ahmad & Çoban, 2025). Given that rural English teachers face profound challenges not just in accessing technology, but in pedagogically executing it to overcome resource disparities, this study strictly focuses on AI teaching

self-efficacy as the primary dependent variable. This distinction ensures that the psychological measurements reflect true pedagogical integration rather than mere technological exposure.

Self-efficacy is a core concept proposed by American psychologist Albert Bandura in the 1970s, referring to an individual's belief in their ability to complete a specific task and achieve expected goals in a specific situation (Bandura, 1977). This belief directly influences an individual's goal setting, degree of effort investment, persistence in the face of difficulties, and emotional regulation, serving as a key psychological mechanism driving behavioral practice. One of its core characteristics lies in its situational specificity: self-efficacy is not a unified assessment of an individual's overall capabilities but is deeply tied to specific tasks and scenarios. The same subject may exhibit distinctly different levels of self-efficacy in different situations. For example, a teacher may demonstrate high self-efficacy in traditional classroom teaching but exhibit low self-efficacy in scenarios like AI-assisted teaching that require the integration of new technologies due to a lack of relevant experience.

Based on this core attribute, AI teaching self-efficacy can be defined as the specific extension of self-efficacy in the context of artificial intelligence education. It specifically refers to teachers' confidence and perceived ability to effectively use AI technology (such as AI oral assessment, personalized tutoring tools, etc.), combined with subject content and pedagogical design of learning activities, and efficiently manage the classroom teaching process in the specific context of AI-assisted English teaching. The proposal of this concept not only aligns with the essential logic of Bandura's self-efficacy theory but also precisely responds to the specific needs of teachers' professional development against the backdrop of the integration of AI and education, providing a clear theoretical anchor for subsequent explorations of rural English teachers' confidence in AI application.

Sun, Yang and Ma's (2022) research indicated that the pre- and post-test means of information technology teachers' AI teaching self-efficacy were 30.78 and 37.78 (out of 50), demonstrating significant improvement after targeted training and further illustrating that AI teaching self-efficacy is malleable. Concurrently, research has also shown that AI teaching self-efficacy is influenced by multiple dimensions, among which technical experience is the strongest predictor for enhancing AI teaching self-efficacy. Teachers' technical anxiety can weaken self-efficacy, whereas technical support from schools and professional development activities can have a positive effect on self-efficacy (Sun et al., 2022). Similarly, AI literacy, especially the cognitive learning dimension within it, can enhance teachers' perceived usefulness and perceived ease of use of AI technology, thereby significantly enhancing their AI teaching self-efficacy; at the same time, collaborative AI projects, resource and training support provided by schools, and incentive measures at the policy level have been proven to be key factors promoting the integration of AI literacy and TPACK (Aglibot et al., 2025).

2.4. The Relationship Between TPACK and AI Teaching Self-Efficacy

Existing research has gradually confirmed a close intrinsic connection between TPACK and teachers' AI teaching self-efficacy, and this connection is supported not solely by singular technological knowledge but by multi-dimensional integrated capabilities. Notably, Celik's (2023) research showed that TK knowledge can better

assist teachers in making decisions related to AI teaching, but basic TK knowledge alone is not enough to effectively integrate artificial intelligence tools into daily educational teaching. Furthermore, an empirical study on Turkish teachers by Hava and Babayiğit (2024) discovered that digital proficiency, as an important support for TPACK capability, can significantly and positively predict AI-TPACK levels, indirectly providing cross-cultural corroboration for how technology integration capability affects AI application confidence. This conclusion further illustrates that merely possessing basic technical operational abilities cannot effectively enhance teachers' self-confidence in AI teaching situations. However, a critical synthesis of recent scholarship reveals contradictory evidence regarding how traditional teaching foundations influence this process. It is found that there is a significant negative correlation between extensive teaching experience and high-order AI-TPACK proficiency, suggesting that ingrained conventional habits can sometimes inhibit technological assimilation. This "translation bottleneck" is particularly evident among primary school English teachers, who possess deep subject expertise but struggle to migrate this into digital integration (Qian, Dandan & Honghui, 2025). Another emerging dimension in this contradiction is psychological readiness; as Şahin (2025) highlighted, explicitly fostering self-regulation is critical for AI-TPACK development, yet senior in-service rural teachers often lack this contemporary psychological scaffolding. These contrasting views highlight that rich disciplinary experience may actually mask a vulnerability in AI teaching self-efficacy if not explicitly bridged by targeted AI-TPACK development. To achieve the deep integration of AI technology and English teaching and to enhance teachers' AI teaching self-efficacy, one must rely on a higher level of holistic TPACK integration capability.

The "technology-pedagogy-content" three-dimensional integration logic emphasized by TPACK highly aligns with the core requirements of AI teaching: AI teaching is not simply the application of technological tools, but requires teachers to combine the characteristics of English subject content and pedagogical requirements, select adaptive AI technologies, and design systematic teaching activities. This process is precisely the concrete practice of TPACK capabilities. Although existing studies have preliminarily revealed the positive impact of technology integration capability on teachers' technical efficacy, there is currently a lack of empirical verification regarding how various dimensions of TPACK affect AI teaching self-efficacy and how overall TPACK capability predicts AI teaching self-efficacy among the specific group of rural English teachers.

In summary, TPACK is a key factor affecting rural English teachers' AI teaching self-efficacy. However, research is scarce on its impact on AI teaching self-efficacy and the specific influence pathways. Therefore, this article takes the TPACK framework as an entry point to test the influence mechanism of overall TPACK on AI teaching self-efficacy.

3. Methods

3.1. Research Questions

To deeply explore the current status and internal correlations of professional capabilities and technological application confidence among rural English teachers, this study proposes the following three research questions, aiming to provide empirical

evidence and practical references for the digital transformation of rural English education and teachers' professional development:

RQ1: How developed are the TPACK capabilities of rural English teachers?

RQ2: What is the level of AI teaching self-efficacy among rural English teachers?

RQ3: How do TPACK capabilities influence the AI teaching self-efficacy of rural English teachers?

3.2. Research Subjects

This study selected 115 in-service primary and secondary school English teachers from rural towns in Maoming and Zhanjiang, western Guangdong, as research subjects. Based on Green's (1991) rule ($N \geq 50 + 8m$), a minimum of 106 participants was required for seven predictors. Our sample of 115 participants thus provided sufficient statistical power.

Table 1: Basic Information of the Sample.

Demographic Variable	Category	Frequency	Valid Percentage (%)
Teaching Stage	Primary School	97	84.3
	Middle School	18	15.7
Years of Teaching	0-5 years	20	17.4
	6-15 years	15	13.0
	Over 15 years	80	69.6

In terms of teaching stage distribution, the survey shows that rural English teachers at the primary school level constitute the main body of this sample, totaling 97 individuals, accounting for 84.3% of the valid sample; rural English teachers at the middle school level number 18, accounting for 15.7%. Considering the actual allocation of educational resources in rural areas, primary education has broader coverage and a greater demand for teachers, so the teaching stage distribution of the sample conforms to the overall occupational characteristics of rural English teachers and is reasonable.

Regarding the composition of teaching years, senior teachers with over 15 years of teaching experience accounted for the highest proportion (69.6%, 80 individuals); followed by young teachers with 0-5 years (17.4%, 20 individuals); teachers with 6-15 years accounted for 13.0% (15 individuals). This distribution indicates that a certain scale of young teachers has joined, and the overall structure remains stable while possessing potential for subsequent development.

3.3. Research Tools

This study adopts a mixed-methods approach combining questionnaires and semi-structured interviews. The questionnaire consists of three parts. The first part investigates basic information about the English teachers, involving years of teaching, teaching stage, and school; the second part uses a 5-point Likert scale (1=strongly disagree, 5=strongly agree) to measure teachers' TPACK levels; the third part uses a 7-point Likert scale (1=strongly disagree, 7=strongly agree) to measure teachers' AI teaching self-efficacy levels.

The TPACK scale was adapted from prior literature. The questionnaire measured

7 dimensions: Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Technological Pedagogical Content Knowledge (TPACK). Each dimension contains 4 items. The scale contains a total of 28 items. The overall scale's Cronbach's alpha coefficient was 0.98, and the reliability for each dimension was good: PK ($\alpha=0.91$), CK ($\alpha=0.91$), TK ($\alpha=0.86$), PCK ($\alpha=0.93$), TPK ($\alpha=0.95$), TCK ($\alpha=0.94$), TPACK ($\alpha=0.96$). Bartlett's test of sphericity for all dimensions reached a significant level ($p<0.001$), KMO value was 0.948, indicating that the data is suitable for factor analysis with good construct validity.

The Teacher Artificial Intelligence Competence Self-Efficacy (TAICS) scale was adapted from Chiu et al. (2025) mature scale, measuring six dimensions: AI Knowledge, AI Pedagogy, AI Assessment, AI Ethics, Human-centric Education, and Professional Engagement, with each dimension containing 4 items. The scale contains a total of 24 items. The overall scale's Cronbach's alpha coefficient was 0.98. The reliability for each dimension was good: AI Knowledge ($\alpha=0.89$), AI Pedagogy ($\alpha=0.95$), AI Assessment ($\alpha=0.96$), AI Ethics ($\alpha=0.92$), Human-centric Education ($\alpha=0.93$), and Professional Engagement ($\alpha=0.90$). Bartlett's test of sphericity for all dimensions reached a significant level ($p<0.001$), KMO value was 0.953, indicating the data is suitable for factor analysis with good construct validity.

The semi-structured interview protocol was specifically designed to explore three core dimensions: (1) teachers' cognitive experiences in distinguishing generative AI from traditional multimedia tools; (2) practical and organizational bottlenecks encountered during AI-assisted pedagogical execution, particularly in assessment; and (3) the psychological mechanisms underlying their technological anxiety and ethical decision-making when facing AI integration challenges.

3.4. Data Collection

Data collection took place between September and November 2025, targeting in-service English teachers from rural primary and secondary schools in Maoming and Zhanjiang, Guangdong Province. To accommodate geographical constraints and facilitate administrative coordination, a convenience sampling approach was employed to recruit participants for the online questionnaire. Subsequently, to ensure adequate representativeness for the qualitative phase, a purposive stratified sampling strategy was utilized to select 10 survey respondents for semi-structured interviews. To overcome temporal and spatial limitations, these interviews were primarily conducted via online voice calls. With the participants' informed consent, all sessions were fully audio-recorded, lasting an average of 30 minutes.

3.5. Data Analysis

The data in this study includes both quantitative and qualitative components, analyzed using corresponding methods.

For quantitative data analysis, SPSS 27.0 was first used to conduct factor analysis on the questionnaire data to verify the scale's validity. The results showed that the Kaiser-Meyer-Olkin (KMO) values for the two scales were 0.948 (TPACK) and 0.953 (AI teaching self-efficacy), respectively, and Bartlett's test of sphericity was significant

($p < 0.001$), indicating good construct validity suitable for questionnaire analysis. Subsequent statistical analyses included: First, descriptive statistics were performed to report the means and standard deviations of the dimensions of TPACK and AI teaching self-efficacy; second, repeated measures ANOVA was conducted to test the differences in teachers' scores across the dimensions of TPACK and AI teaching self-efficacy; finally, linear regression analysis was performed to explore the predictive effect of rural English teachers' TPACK capabilities on their AI teaching self-efficacy.

The qualitative data from interviews was analyzed using the grounded theory coding method (Strauss & Corbin, 1998), with the following standardized coding procedure: First, the 10 interview recordings were transcribed verbatim to form the original text data; second, line-by-line coding of the original text was conducted to extract initial concepts and categories; third, the logical relationships between initial categories were sorted out to refine main categories and sub-categories; finally, focusing on the core research questions, the core categories were extracted, and the storyline between categories was constructed to supplement and interpret the quantitative results.

To ensure the reliability of qualitative data analysis, two trained researchers independently completed the coding work. The inter-coder reliability Kappa coefficient was 0.87, yielding a value of 0.87. According to qualitative research standards, a Kappa value between 0.81 and 1.00 indicates "almost perfect" agreement, demonstrating a high degree of objectivity and consistency in the coding process and effectively minimizing subjective bias.

4. Research Results

4.1. Current Development Status of Rural English Teachers' TPACK Capabilities

The overall average score of rural English teachers' self-perceived TPACK literacy was 3.78 (SD=0.81) on a 5-point Likert scale, indicating an upper-middle level of overall capability.

To test the differences in teachers' scores across the TPACK dimensions, a repeated measures ANOVA was conducted on the 7 TPACK dimensions. Results showed a highly significant overall difference in the scores of the TPACK dimensions. Because the data violated the assumption of sphericity, the Greenhouse-Geisser correction was applied ($F(2.23, 254.64)=13.78, p < 0.001$). As shown in Table 2, rather than uniform proficiency, the teachers exhibited a highly uneven developmental profile in their TPACK capabilities. While they demonstrated robust foundational pedagogical knowledge (PK) and content knowledge (CK), a pronounced deficiency emerged in Technological Content Knowledge (TCK), which recorded the lowest mean score. This indicates that extensive traditional teaching experience does not naturally translate into the higher-order cognitive ability required to deeply integrate technology with subject-specific content.

As shown in Table 3, the overall TPACK literacy of rural English teachers is at an upper-middle level. However, a significant capability imbalance exists: teachers scored highest in foundational Pedagogical Knowledge (PK) and Content Knowledge (CK), but lowest in Technological Content Knowledge (TCK). This "foundation-heavy, integration-light" profile suggests that while these educators possess strong traditional

pedagogical skills, they struggle with the higher-order synthesis of digital tools and subject content. Furthermore, wider standard deviations in intersectional dimensions like TPK and TCK highlight substantial capability heterogeneity within the cohort.

Table 2: Descriptive Statistics of Rural English Teachers' TPACK Dimension Scores.

Dimension	N	M	SD
PK	115	15.98	3.30
CK	115	15.80	3.39
TK	115	14.63	3.43
PCK	115	15.30	3.41
TPK	115	16.74	6.23
TCK	115	14.32	3.84
TPACK	115	14.97	3.68

(Note: N=Sample size, M=Mean, SD=Standard Deviation)

Table 3: Descriptive Statistics of Primary and Middle School English Teachers' Self-Perceived TPACK Literacy.

Dimension	N	M	SD
Total TPACK	115	3.78	.81
PK	115	4.00	.83
CK	115	3.95	.85
TK	115	3.66	.86
PCK	115	3.82	.85
TPK	115	3.68	.98
TCK	115	3.58	.96
TPACK	115	3.74	.92

4.2. Rural English Teachers' AI Teaching Self-Efficacy

The overall average score of rural English teachers' AI teaching self-efficacy was 4.30 (SD=1.46) on a 7-point Likert scale, indicating an upper-middle level of overall self-efficacy.

Table 4: Descriptive Statistics of Primary and Middle School English Teachers' AI Teaching Self-Efficacy.

Dimension	N	M	SD
TAICS(Total)	115	4.30	1.46
AI Knowledge	115	4.47	1.45
AI Pedagogy	115	4.41	1.53
AI Assessment	115	4.10	1.70
AI Ethics	115	4.40	1.57
Human-centric Education	115	4.18	1.56
Professional Engagement	115	4.22	1.60

(Note: N=Sample size, M=Mean, SD=Standard Deviation, TAICS=Teacher AI Competence Self-efficacy overall status)

To test the differences in teachers' scores across the dimensions of AI teaching

self-efficacy, a repeated measures ANOVA was conducted on its 6 dimensions. Results revealed highly significant overall differences across AI teaching self-efficacy dimension scores (Greenhouse-Geisser correction, $F(4.05, 50.83) = 6.44, p < 0.001$). Among them, the AI Knowledge dimension scored highest ($M = 17.90, SD = 5.80$), and the AI Assessment dimension scored lowest ($M = 16.40, SD = 6.80$). Mauchly's test of sphericity showed that the analysis did not meet the sphericity assumption ($p < 0.001$), hence the results after Greenhouse-Geisser correction are reported.

Table 4 indicates an upper-middle overall AI teaching self-efficacy. Notably, the data reveals a stark gap between theoretical comprehension and practical execution. Teachers reported the highest confidence in foundational AI Knowledge, but the lowest in AI Assessment. This hierarchy highlights that while rural English teachers grasp basic AI concepts and ethical considerations, they currently lack the actionable confidence required to orchestrate complex, high-stakes pedagogical tasks.

4.3. The Significant Positive Impact of Rural English Teachers' TPACK Capabilities on AI Teaching Self-Efficacy

To clarify the specific correlation between rural English teachers' TPACK capability and AI teaching self-efficacy (TAICS), this study conducted a linear regression analysis using TPACK capability as the predictor variable and AI teaching self-efficacy as the dependent variable.

Table 5: Correlation Analysis Results between TPACK Capability and AI Teaching Self-Efficacy (TAICS).

Variables		TPACK	TAICS
TPACK	Pearson Correlation	1	.650**
	Sig. (2-tailed)		.000
	N	115	115
TAICS	Pearson Correlation	.650**	1
	Sig. (2-tailed)	.000	
	N	115	115
(* Correlation is significant at the 0.01 level (2-tailed).)*			

The regression model fitting results show that the model's R value is 0.65, and the adjusted R^2 is 0.41, indicating that TPACK capability can explain 41.2% of the variance in AI teaching self-efficacy, showing good model fit. ANOVA results show an F value of 80.86 ($p < 0.001$), indicating that the regression model is statistically significant, and the overall predictive effect of TPACK capability on AI teaching self-efficacy is significant.

Equation coefficient test results show that rural English teachers' TPACK capability has a significant positive predictive effect on their AI teaching self-efficacy ($\beta = 0.65, t = 8.99, p < 0.001$), meaning the higher the level of a teacher's TPACK capability, the stronger their self-efficacy in AI teaching-related practices. Combined with the previous Pearson correlation analysis results ($r = 0.65, p < 0.001$), this further verifies the tight positive correlation between the two, providing empirical support for the collaborative enhancement of "technology-pedagogy-content" integration capabilities and AI application confidence in the professional development of rural English teachers.

Table 6: Equation Coefficient Test Table.

Model	Coefficient ^a						
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower	Upper
(Constant)	-1.87	11.94		-.16	.876	-25.53	21.79
TPACK	.99	.11	.65	8.99	.000	.77	1.21
(Note: a=Dependent Variable: TAICS.)							

5. Discussion

5.1. The Current Development Status of Rural English Teachers' TPACK Capabilities

The survey found that the overall average score for rural English teachers' TPACK capability is 3.78 (on a 5-point Likert scale). According to scale scoring rules and general judgment standards in educational research, this is at an upper-middle level. Various dimensions present an uneven characteristic of “relatively solid basic theory, weak higher-order integration,” which highly aligns with the phased characteristics of the “uneven advancement” of the digital transformation of rural education in China. Pedagogical Knowledge (PK) and Content Knowledge (CK) scored the highest. This pattern reflects the sample composition (69.6% with over 15 years of teaching experience): senior teachers in rural China have historically received in-service training that emphasizes subject pedagogy over technology, which would naturally inflate PK and CK scores relative to technology-related dimensions. Through years of classroom refinement and teaching research activities, senior teachers have built solid foundational professional capabilities, which serve as the core support for their TPACK capabilities and lay the foundation for pedagogical and subject literacy in the integration of AI and English teaching.

Conversely, Technological Content Knowledge (TCK) scored the lowest, and Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK) scored relatively lower. The fact that TCK (M = 3.58) was even lower than TK (M = 3.66) suggests that the core deficiency has shifted from basic technical operation to the cognitive integration of technology with subject content—a higher-order skill that requires not just tool familiarity but sustained, contextualized practice. This result reveals the core shortcomings of rural English teachers at the level of deep integration of technology and subject matter. Zhao and Yang (2025), in their “AI + Rural English Teacher Training” project, observed that while rural English teachers had begun using AI tools for pronunciation practice, they still lacked systematic cognition of deeper applications such as data analysis and personalized exercise generation—precisely the functions in which TCK and TPK interact. This directly results in AI tools being used only at a superficial assistive level, making it difficult to realize deep empowerment of technology for subject instruction. For example, multiple teachers mentioned in interviews that although rural schools are equipped with basic information tools such as Seewo whiteboards and national smart platforms, teachers' frequency and depth of use are limited, and their cognition of AI tools is relatively vague. This indicates that teachers' technical knowledge remains at the traditional multimedia level, lacking systematic cognition and practical opportunities for emerging AI technologies. On the

other hand, although senior teachers have rich teaching experience, some may have low technology acceptance and insufficient willingness for digital learning, resulting in slow updates of technical knowledge and difficulty in effectively transforming technology into tools for teaching optimization (Xie & Wang, 2024). For instance, teachers mentioned in interviews that they “flexibly select” tech tools in teaching, but it is more often a case of “determining the teaching activity first, then looking for tech support,” rather than deep integration. Although some teachers attempt to use AI to analyze student grades and generate personalized feedback, such cases remain a minority among rural teachers, showing that the systematic integration of technology and teaching is still in an exploratory stage. Furthermore, the large standard deviations in certain dimensions reflect the capability heterogeneity within the teacher group, which may correlate with factors like years of teaching, learning motivation, and school technical support—younger teachers are more receptive to new technologies, and schools equipped with comprehensive tech resources and training systems have teachers with relatively stronger technology application capabilities.

5.2. The Current Status of Rural English Teachers’ AI Teaching Self-Efficacy

Rural English teachers’ AI teaching self-efficacy is generally at an upper-middle level (overall average score 4.30), and various dimensions present a distribution characteristic of “knowledge mastery surpassing practical application,” consistent with the realistic context of current AI education promotion. The AI Knowledge dimension scored the highest. For example, interviewed teachers generally had heard of tools like “Doubao,” “DeepSeek,” and “Kouyu 100,” and could list their basic functions, illustrating that under the promotion of education digitization policies, rural English teachers have initially mastered the basic theoretical knowledge of AI teaching through various training and online learning channels, forming a fundamental understanding of AI tools’ functions and application scenarios. Conversely, the AI Assessment dimension scored the lowest. Interviewed teachers mentioned that AI grading inaccurately identifies non-standard handwriting, and students’ weak foundations coupled with insufficient equipment (e.g., poor network, outdated systems) further impact effectiveness. Another teacher pointed out that when using AI oral assessment in parallel classes, student’ “poor self-discipline” and “inability to understand” compromise the assessment effectiveness. These practical difficulties weaken teachers’ confidence in AI assessment, reflecting insufficient capabilities and confidence in higher-order practical aspects of AI teaching—AI teaching assessment requires teachers to possess comprehensive capabilities in data interpretation, personalized analysis, and teaching improvement, deeply combining AI tools with English teaching assessment logic, which is a major challenge for rural teachers.

Looking at other dimensions, AI Pedagogy and AI Ethics scored relatively high, showing that teachers not only focus on the application of AI in teaching but also value ethical issues during AI usage (such as student privacy protection and data security), reflecting the rigorous teaching attitude of rural teachers (Xiao et al., 2026). However, the scores for Professional Engagement and Human-centric Education lay in the middle, reflecting limited participation in professional exchanges and collaborative learning related to AI teaching, and indicating room for improvement in their cognition of “integrating AI technology with humanistic care.” This situation is

closely related to resource constraints in rural education: rural schools lack platforms for exchanging AI teaching practices, making it difficult for teachers to obtain peer support and expert guidance; meanwhile, the operational complexity of AI tools and insufficient adaptability to the reality of rural English teaching lower teachers' confidence in practical application. Furthermore, the teaching stage distribution of the sample is dominated by primary school teachers (84.3%). Primary English teaching focuses more on cultivating basic language skills, where application scenarios for AI assessment tools are relatively limited, which may also contribute to the teachers' lower self-efficacy in this dimension.

5.3. The Relationship Between TPACK Capabilities and AI Teaching Self-Efficacy

Pearson correlation analysis and linear regression analysis confirmed that there is a significant strong positive correlation between rural English teachers' TPACK capabilities and AI teaching self-efficacy ($r=0.65$, $p<0.001$), and that TPACK capability explains 41.2% of the variance in AI teaching self-efficacy. This result verifies the core supporting role of "technology-pedagogy-content" integration capability in AI teaching practice. TPACK capabilities encompass technological knowledge, pedagogical knowledge, subject content knowledge, and the integrated capability of all three; AI teaching is fundamentally a practical activity of deeply integrating technology with teaching and subject content. Therefore, solid TPACK literacy helps teachers break through multiple dilemmas in AI teaching applications (Xiao et al., 2026).

Specifically, Content Knowledge (CK) and Pedagogical Knowledge (PK) form the foundation of AI teaching: teachers must deeply understand the teaching objectives, content system, and teaching laws of the English subject to clarify the application needs for AI tools and select adaptive AI resources. Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK) are the keys to AI teaching: teachers must master the operational methods and technical principles of AI tools to effectively apply them in classroom teaching and homework design. Meanwhile, Technological Pedagogical Content Knowledge (TPACK) is the core of AI teaching: teachers must combine AI technology with specific scenarios in English teaching to achieve the ultimate goal of "technology serving teaching objectives and promoting student learning" (Zhao & Yang, 2025). Therefore, teachers with higher TPACK capabilities can more clearly grasp the logical essence of AI teaching, are more capable of solving problems when facing technical application difficulties, and naturally exhibit stronger self-efficacy (Liu, 2021).

This research result aligns with existing related findings that teachers' technology integration capability is a vital factor affecting their technology application self-efficacy (Hava & Babayiğit, 2024; Liu, 2021). Research by Hava and Babayiğit (2024) on 401 Turkish teachers found that digital proficiency indirectly supports teachers' AI application capability by improving AI-TPACK levels, which echoes cross-culturally with this study's conclusion that "TPACK integration capability predicts AI teaching self-efficacy." Simultaneously, this result provides a clear direction for improving the AI teaching capabilities of rural English teachers: to enhance AI teaching self-efficacy, one must not only focus on teaching AI knowledge but also emphasize the systematic cultivation of TPACK literacy, while balancing the improvement of digital proficiency. Strengthening the integrated capability of technology, pedagogy, and content help teachers build confidence and capability in AI teaching. Furthermore, the findings

reflect that rural English teachers still have substantial room for improving their AI teaching self-efficacy; besides enhancing TPACK capabilities, complementary external resources such as technical support, training systems, and communication platforms are needed to fully stimulate teachers' enthusiasm for AI teaching (Zhao & Yang, 2025). For example, three interviewed teachers mentioned that sharing AI usage experiences through "colleague sharing," "cross-school exchanges," and "WeChat groups" can significantly boost confidence in usage. Conversely, teachers in schools lacking collaboration rely more on self-study and progress slowly. This illustrates that the development of TPACK capabilities is not solely an individual learning process but also relies on community support.

5.4. Limitations and Future Research

This study has several limitations that warrant consideration. First, the geographical scope is limited to the rural areas of western Guangdong, China. Given the significant regional disparities in educational infrastructure across the country, the external validity of these findings may be restricted. Future research should employ stratified random sampling across diverse regions to verify the generalizability of the AI-TPACK predictive mechanisms. Second, an imbalance exists in the sample composition, with 84.3% being primary school teachers. In light of this, the results might not be applicable to secondary schools. This disproportion may obscure the unique technological and psychological characteristics of middle school educators, who often face more complex AI integration demands. Third, the reliance on self-reported questionnaire data introduces the potential for social desirability bias, wherein teachers might overestimate their technological openness. Future studies would benefit from incorporating multi-modal data, such as classroom observations and system logs, to triangulate the findings. Finally, the cross-sectional design of this study captures only a temporal snapshot, which restricts the ability to establish absolute causal relationships between TPACK capabilities and AI teaching self-efficacy. Longitudinal tracking studies are urgently needed to map the dynamic evolution of teachers' digital competencies over time.

6. Conclusion

From the perspective of TPACK theory, this study selected rural English teachers in western Guangdong as research subjects and explored the current status and influence mechanisms between their TPACK capabilities and AI teaching self-efficacy through mixed research methods. The study found that rural English teachers' TPACK capabilities and AI teaching self-efficacy are both at an upper-middle level. The former presents a characteristic of relatively solid foundational theory but weak higher-order integration, while the latter demonstrates knowledge mastery surpassing practical application. Moreover, TPACK capability has a significant positive predictive effect on AI teaching self-efficacy.

This study provides a practical reference for the professional development of rural English teachers and the implementation of AI teaching in rural areas, while also supplementing rural empirical evidence for the application of TPACK theory in AI education scenarios. Future research could further expand the geographical and teaching stage scope of the sample to enrich the universality of the research findings; it could also deeply explore the specific influence pathways of various

TPACK dimensions on AI teaching self-efficacy and unearth relevant mediating and moderating variables. Concurrently, highly actionable TPACK literacy training programs can be designed based on the findings, optimizing the adaptability of AI teaching tools in conjunction with the realities of rural teaching, and constructing a diversified support system to promote the deep integration of AI technology and rural English teaching, assisting in the high-quality digital development of rural education.

Theoretical contributions of this study lie in demarcating the boundary between general technological acceptance and specific AI teaching self-efficacy. By empirically validating the indispensable predictive role of holistic TPACK capabilities on the TAICS construct, this study enriches the AI-TPACK theoretical corpus with vital evidence from resource-constrained rural environments. Practically, this research issues an urgent call to innovate current rural teacher training models. It necessitates the abandonment of fragmented, tool-centric training approaches in favor of sustained, collaborative peer-support networks that explicitly scaffold the integration of AI into specific English teaching workflows. Only through such profound capacity-building can the vicious cycle of low AI literacy and low teaching efficacy be dismantled, ensuring that AI serves as a true catalyst for equitable educational development.

References

- Aglibot, K. A., Rito, C. L., Villalon, L. & Gampal, N. (2025). The future of teaching: Analyzing the interplay between AI literacy and TPACK among BEED pre-service teachers. *Journal of Artificial Intelligence in Education & Learning Innovation*, 1(1), pp. 50–65. doi: <https://doi.org/10.56003/jaieli.v1i1.570>
- Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, 84(2), pp. 191–215. doi: <https://doi.org/10.1037/0033-295X.84.2.191>
- Castro, A., Díaz, B., Aguilera, C., Prat, M. & Chávez-Herting, D. (2025). Identifying Rural Elementary Teachers' Perception Challenges and Opportunities in Integrating Artificial Intelligence in Teaching Practices. *Sustainability*, 17(6), pp. 2748. doi: <https://doi.org/10.3390/su17062748>
- Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior*, 138, pp. 107468. doi: <https://doi.org/10.1016/j.chb.2022.107468>
- Cheng, Y., Ma, Z., Lyu, H., Fu, Y. & Yang, Y. (2024). A Study on the Cultivation Strategies for Pre-Service Teachers' Intelligent Educational Literacy in Blended Learning. In *Proceedings of the 3rd International Conference on Educational Innovation and Multimedia Technology*. EAI. doi: <https://doi.org/10.4108/eai.29-3-2024.2347754>
- Chiu, T. K. F., Ahmad, Z. & Çoban, M. (2025). Development and validation of teacher artificial intelligence (AI) competence self-efficacy (TAICS) scale. *Education and Information Technologies*, 30(5), pp. 6667–6685. doi: <https://doi.org/10.1007/s10639-024-13094-z>
- Elifas, T. N. & Simuja, C. (2024). The pedagogical insights of mathematics teachers integrating artificial intelligence in rural upper primary schools of Namibia. *Interdisciplinary Journal of Education Research*, 6, pp. 1–14. doi: <https://doi.org/10.38140/ijer-2024.vol6.37>

- Green, S. B. (1991). How Many Subjects Does It Take To Do A Regression Analysis. *Multivariate Behavioral Research*, 26(3), pp. 499–510. doi: https://doi.org/10.1207/s15327906mbr2603_7
- Hava, K. & Babayiğit, Ö. (2024). Exploring the relationship between teachers' competencies in AI-TPACK and digital proficiency. *Education and Information Technologies*, 30(3), pp. 3491–3508. doi: <https://doi.org/10.1007/s10639-024-12939-x>
- Kim, S., Jang, Y., Choi, S., Kim, W., Jung, H., Kim, S., et al. (2021). Analyzing Teacher Competency with TPACK for K-12 AI Education. *KI - Künstliche Intelligenz*, 35(2), pp. 139–151. doi: <https://doi.org/10.1007/s13218-021-00731-9>
- Komarudin, K. & Suherman, S. (2024). An Assessment of Technological Pedagogical Content Knowledge (TPACK) among Pre-service Teachers. *Pixel-Bit*, 71, pp. 59–82. doi: <https://doi.org/10.12795/pixelbit.107599>
- Li, S., Liu, Y. & Su, Y.-S. (2022). Differential Analysis of Teachers' Technological Pedagogical Content Knowledge (TPACK) Abilities According to Teaching Stages and Educational Levels. *Sustainability*, 14(12), pp. 7176. doi: <https://doi.org/10.3390/su14127176>
- Liu, Y. (2021). AI-Powered Teacher Training: Educational Implications and Practical Dimensions. *Research on Educational Technology*, 42(1), pp. 64–71. doi: <https://doi.org/10.13811/j.cnki.eer.2021.01.009>
- Mishra, P. & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record*, 108(6), pp. 1017–1054. doi: <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- Mishra, P., Warr, M. & Islam, R. (2023). TPACK in the age of ChatGPT and Generative AI. *Journal of Digital Learning in Teacher Education*, 39(4), pp. 235–251. doi: <https://doi.org/10.1080/21532974.2023.2247480>
- Qian, L., Dandan, T. & Honghui, L. (2025). Current Situation and Promotion of TPACK Strategies Among Primary School English Teachers in The Era of Artificial Intelligence. *Journal of Advances in Humanities Research*, 4(1), pp. 1–21. doi: <https://doi.org/10.56868/jadur.v4i1.286>
- Rakes, C. R., Stites, M. L., Ronau, R. N., Bush, S. B., Fisher, M. H., Safi, F., et al. (2022). Teaching Mathematics with Technology: TPACK and Effective Teaching Practices. *Education Sciences*, 12(2), pp. 133. doi: <https://doi.org/10.3390/educsci12020133>
- Resbianoro, G. (2017). Self-Efficacies of Prospective Mathematic Teachers' Technological Pedagogical Content Knowledge (TPACK). *Jurnal Varidika*, 28(2), pp. 102–115. doi: <https://doi.org/10.23917/varidika.v28i2.2735>
- Şahin, M. (2025). Analyzing the Foundations of Social Sustainability in Teacher Education: A Study of Self-Regulation, Social-Emotional Expertise, and AI-TPACK. *Sustainability*, 17(19), pp. 8613. doi: <https://doi.org/10.3390/su17198613>
- Strauss, A. & Corbin, J. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Sage Publications.

- Sun, J., Yang, Y. & Ma, H. (2022). Research on Improving the AI Teaching Self-Efficacy of Information Technology Teachers. *The Journal of Xinyang Normal University (Philosophy and Social Science Edition)*, 42(6), pp. 50–57. doi: <https://doi.org/10.3969/j.issn.1003-0964.2022.06.009>
- Wu, D. & Bai, J. (2025). Enhancing Teachers' and Students' Artificial Intelligence Literacy to Promote the Digital Transformation of Education. *Cyber Affairs of China*, (8), pp. 50–54.
- Xiao, H., Li, X., Cheng, S. & Chen, X. (2026). Current Status and Prospects of AI Literacy Research at Home and Abroad: A Systematic Literature Review. *Library Development*. Retrieved from <https://link.cnki.net/urlid/23.1331.G2.20260131.1513.002>
- Xie, Z. & Wang, H. (2024). The Influence of Digital Continuous Professional Development on Rural Teachers' Digital Teaching Literacy—Examining the Mediating Roles of Sense of Organizational Support and Digital Teaching Self-Efficacy. *Journal of South China Normal University (Social Science Edition)*, (1), pp. 105–116. Retrieved from <https://journal-s.scnu.edu.cn/cn/article/pdf/preview/031eaa6d-bca7-4744-b6fa-e2a7cd21c997.pdf>
- Zhang, W. & Tang, J. (2021). Teachers' TPACK Development: A Review of Literature. *Open Journal of Social Sciences*, 9(7), pp. 367–380. doi: <https://doi.org/10.4236/jss.2021.97027>
- Zhao, Y. & Yang, L. (2025). Exploration of a Precision Assistance Model for Foreign Language Education in the New Era Based on the TPACK Model: A Case Study of the "Artificial Intelligence + Rural English Teacher Training" Project. *Foreign Language World*, (2), pp. 73–79. Retrieved from <http://www.waiyujie.net/CN/Y2025/V0/I2/73>