International Journal of Learning, Teaching and Educational Research
Vol. 25, No. 3, pp. 655-679 March 2026
https://doi.org/10.26803/ijlter.25.3.28
Received Jan 28, 2026; Revised Feb 27, 2026; Accepted Mar 1, 2026

Bridging the AI-TPACK Chasm: The Impact of Faculty AI Literacy on Pedagogical Quality and Scholarly Output in Higher Education

Fatimah Ali ALhuraybi
Department of Psychology, College of Education in Al-Kharj,
Prince Sattam Bin Abdulaziz University, Al-Kharj, Saudi Arabia

Mohammed Rahmath*
Department of Computer Engineering and Information,
College of Engineering in Al-Kharj, Prince Sattam Bin Abdulaziz University,
Saudi Arabia

Mohamed Sayed Abdellatif
Department of Psychology, College of Education in Al-Kharj,
Prince Sattam Bin Abdulaziz University, Al-Kharj, Saudi Arabia

Mohamed Mekheimer
Department of Teaching English to Speakers of Other Languages (TESOL),
Faculty of Education, Beni-Suef University,
Beni-Suef City 62511, Egypt

Walid Abdelhalim
Department of Foundations of Education,
Faculty of Education, Beni-Suef University, Beni-Suef City,
East Nile Campus, Egypt

Abstract. Generative artificial intelligence (AI) is rapidly reshaping higher education, yet evidence on how faculty AI literacy relates to concrete outcomes remains limited. Using a cross-sectional survey with embedded qualitative open-ended responses, this study examined whether faculty AI literacy predicts self-reported pedagogical practices quality and scholarly productivity. An online questionnaire was completed by 691 university faculty members and modeled relationships among four AI literacy dimensions—conceptual knowledge, application skills, ethical/critical awareness, and pedagogical integration (AI-TPACK)—and two outcomes, pedagogical practices quality and scholarly

*Corresponding author: Mohammed Rahmath; *rm.mohammed@psau.edu.sa*

productivity (in the past three years). Hierarchical regression and ANOVA were used for the quantitative analyses, and narrative responses were thematically analyzed to contextualize and explain key patterns. Conceptual knowledge and pedagogical integration showed the strongest unique positive associations with both outcomes. Ethical/critical awareness showed a small negative association with pedagogical quality once design-oriented competencies were controlled, suggesting a potential 'caution trap' in which risk awareness without integration corresponds to more conservative teaching choices. Qualitative comments highlighted boundary-setting, institutional policy gaps, and unequal access to training across disciplines and career stages. The findings support targeted faculty development that integrates conceptual, ethical, and design-based AI competencies; however, because measures are self-reported and cross-sectional, conclusions should be interpreted as associations, rather than causal effects.

Keywords: AI literacy; AI-TPACK; generative AI; AI ethics; mixed-methods; predictive modeling; faculty development; Saudi Arabia

1. Introduction

Higher education is currently navigating a radical institutional transformation driven by the rapid proliferation of artificial intelligence (AI) technologies. The emergence of large language models and generative AI has moved beyond the periphery of educational technology to become a central determinant of institutional relevance and competitiveness. Recent reviews and syntheses suggest that AI is no longer a marginal educational technology issue but a major structuring force in educational systems, with implications for curriculum, pedagogy, assessment, and institutional strategy (Ifenthaler et al., 2024; Kazimova et al., 2025; Marengo et al., 2024; Mohammed et al., 2024; Mustafa et al., 2024; Garzón et al., 2025; Ma, 2025).

Despite the accelerating ubiquity of AI tools, emerging evidence points to a widening AI competency gap within the academic workforce. This gap is also consistent with emerging work on teacher and educator attitudes, acceptance, and preparedness for AI, which suggests that confidence, literacy, and willingness to adopt AI vary substantially across educational actors and contexts (Aghaziarati et al., 2023; Barakat et al., 2024; Hasanein & Sobaih, 2023; Kaya & Adıgüzel, 2025; Haroud & Saqri, 2025; Mutanga et al., 2024; Yim & Wegerif, 2024; Zakaria & Hashim, 2024).

Students are rapidly adopting generative AI (GenAI) for writing, summarizing, coding, and assessment-related tasks, while faculty adoption is often impeded by deficits in AI literacy that extend beyond technical operation, to include ethical reasoning, critical evaluation, and pedagogical adaptation. This broader framing also aligns with emerging work on AI literacy and competence in language education and educator competence frameworks, which treats literacy as conceptual, evaluative, and pedagogical, rather than merely operational (Ma et al., 2024; Mekheimer & Abdelhalim, 2026; Zou et al., 2025). This asymmetry threatens both academic integrity and curricular relevance.

Traditional assessment formats that do not account for AI capabilities are increasingly vulnerable to AI-enabled plagiarism, while faculty who lack AI literacy cannot provide adequate guidance to students navigating AI-augmented academic and professional environments. This asymmetry is sharpened by evidence that students are already using GenAI widely and often strategically, including for learning support, convenience, and performance-related benefits, which can outpace faculty readiness to respond pedagogically (Dube et al., 2024; Niloy et al., 2024; Monib et al., 2025; Onal & Kulavuz-Onal, 2025).

At the same time, faculty who underutilize or misuse AI tools risk foregoing significant gains in scholarly efficiency or, worse, engaging in unethical research practices due to uncritical reliance on hallucinated outputs and fabricated citations. This concern aligns with a growing body of higher-education reviews documenting both the opportunities and the risks of ChatGPT and related GenAI tools in academic work, including their implications for learning, academic practice, and institutional adoption (Dimeli & Kostas, 2025; Phokoye et al., 2025; Salih et al., 2024; Sok & Heng, 2024; Sposato, 2025; Yang et al., 2024).

In this context, the capacity to develop AI-augmented technological pedagogical content knowledge (AI-TPACK) becomes central to educational quality: not only must teachers be able to operate AI tools but also to redesign tasks, assessments, and feedback in ways that are pedagogically sound and ethically responsible.

The present study builds on the established TPACK tradition that conceptualizes teachers' technological, pedagogical, and content knowledge as interrelated domains, rather than isolated skill sets (Herring et al., 2016), a position reinforced by later reviews, bibliometric analyses, scale-development studies, and construct-validation work showing that TPACK functions as a multidimensional and empirically distinguishable knowledge structure (Zhang & Tang, 2021; Zou et al., 2022; Yurdakul et al., 2012; Kopcha et al., 2014; Khine et al., 2017; Pamuk et al., 2015), while pre-service studies highlight uneven, context-dependent growth across components (Pamuk, 2012; Redmond & Lock, 2019).

These foundational contributions position TPACK as a robust baseline for examining how new waves of disruptive technologies—such as generative AI—are being integrated into pedagogical practice. Intervention and teacher-education studies likewise suggest that TPACK develops through structured design, professional learning, and targeted support, rather than through exposure to tools alone (Beri & Sharma, 2021; Fabian et al., 2024; Lachner et al., 2021).

1.1 Problem Statement

Since the public release of ChatGPT, research on GenAI in education has expanded rapidly, documenting both potential benefits (e.g., feedback, drafting, personalization) and risks (e.g., hallucinations, bias, and integrity concerns) (Albadarin et al., 2024; Ali, Fatemi et al., 2024). However, much of this evidence remains descriptive and focuses on attitudes or intentions, rather than faculty competencies that shape day-to-day teaching and research outcomes. This study

responded by assessing faculty AI literacy and linking it to pedagogical practices quality and scholarly productivity in higher education.

Current institutional narratives often treat AI adoption as a simple matter of individual enthusiasm or resistance. Recent adoption research suggests that AI uptake is shaped not only by personal preference but also by pedagogical beliefs, perceived usefulness, institutional conditions, and social legitimacy (Cabero-Almenara et al., 2024; Barakat et al., 2024; Molefi et al., 2024). However, a more consequential risk is emerging: faculty AI illiteracy can become a systemic quality problem—undermining assessment validity, weakening learning experiences that should prepare students for AI-augmented workplaces, and shaping research practices that are either inefficient or ethically fragile. While a small group of innovators are already experimenting with AI-supported teaching and research, many colleagues remain uncertain, anxious, or underprepared.

This pattern is evident in studies of lecturers' and university teachers' perceptions, which repeatedly report uncertainty, mixed attitudes, and uneven readiness to integrate AI into teaching and assessment (Mutanga et al., 2024; Nguyen, 2023; Har, 2023; Fuentes et al., 2024). The result is a structural AI-TPACK chasm between early adopters and the broader faculty body, with clear downstream consequences for student outcomes and, ultimately, institutional credibility and reputation. This divide is also consistent with evidence that organizational support, available resources, and prior pedagogical-technical capacity shape whether educators move from cautious awareness to meaningful adoption (Molefi et al., 2024; Oved & Alt, 2025; Brandão et al., 2024).

1.2 Purpose of the Study

The primary purpose of this study was to develop and apply a quantitative diagnostic framework to assess AI literacy among university faculty and to determine its impact on pedagogical and research-related outcomes. Specifically, the study aimed to:

1. Measure faculty AI literacy across four dimensions—conceptual knowledge, application skills, ethical and critical awareness, and pedagogical integration (AI-TPACK).
2. Examine the predictive power of these dimensions for (a) perceived quality of pedagogical practices and (b) self-reported scholarly productivity.
3. Explore how patterns of AI literacy and outcomes vary across academic ranks and disciplinary clusters.

This study shifted attention away from whether faculty intended to use AI and toward the consequences of lacking the competencies required for responsible and effective use.

1.3 Research Questions

The study addressed the following research questions:

1. What is the prevailing level of faculty AI literacy across four dimensions—conceptual knowledge, application skills, ethical and critical awareness, and pedagogical integration (AI-TPACK)—within the higher education context?

2. To what extent do the four AI literacy dimensions predict (a) the quality of pedagogical practices and (b) the efficiency of scholarly output among university faculty in higher education?
3. How do faculty AI literacy levels and the two outcome variables—pedagogical practice quality and scholarly output efficiency—differ by academic rank and disciplinary cluster, and what do these differences suggest about an AI-TPACK chasm in higher education?
4. What themes emerge from faculty qualitative narratives (e.g., open-ended responses) regarding barriers, enabling conditions, and support needs for responsible and effective AI use in higher education?

2. Literature Review

This literature review situates the study within scholarship on technology integration in higher education and the recent shift toward AI-specific competence frameworks. This positioning is warranted by recent reviews that map the rapid expansion of AI-in-education scholarship and call for clearer conceptual organization around competencies, use cases, and educational purposes (Mustafa et al., 2024; Mohammed et al., 2024; Marengo et al., 2024; Ma, 2025). The review first traces the conceptual evolution from the TPACK model to AI-oriented extensions (e.g., intelligent-TPACK/AI-TPACK), clarifying how faculty knowledge, skills, and ethical judgment intersect with pedagogical decision-making.

This shift is also reflected in recent work on educator preparation, teacher training, and AI competence frameworks, which increasingly argues that AI-related competence must be treated as a structured extension of technology integration knowledge, rather than as a generic digital add-on (Black et al., 2024; David et al., 2025; Memarian & Doleck, 2024). It then synthesizes evidence on faculty AI literacy, adoption barriers, and institutional conditions that shape teaching practice and scholarly work, establishing the theoretical basis for the study's variables and research questions.

2.1 From TPACK to Intelligent-TPACK

The integration of digital technologies into teaching has traditionally been conceptualized via the TPACK framework, which posits that effective instruction results from the dynamic intersection of content knowledge, pedagogical knowledge, and technological knowledge. TPACK research has demonstrated that teachers who can orchestrate these domains tend to design richer, more coherent technology-enhanced learning experiences. This conclusion is consistent with reviews of TPACK literature, as well as with instrument-development, validity, and relationship studies showing that the framework captures meaningful differences in teachers' technology-related instructional knowledge (Zhang & Tang, 2021; Zou et al., 2022; Yurdakul et al., 2012; Kopcha et al., 2014; Khine et al., 2017; Pamuk et al., 2015).

However, the advent of generative AI fundamentally disrupts this model. Unlike static digital tools, AI systems exhibit a form of functional agency: they generate text, images, and code; simulate feedback; and interact conversationally with

students. This shifts AI from a mere instructional medium to a semi-autonomous collaborator, raising new pedagogical and ethical questions that exceed the scope of traditional TPACK. This broader reconceptualization is also supported by AI-in-education reviews that emphasize both the instructional affordances and the pedagogical complications of AI systems across learning contexts (Chichekian & Benteux, 2022; Díaz & Nussbaum, 2024; Crompton et al., 2024; Garcia et al., 2025; Garzón et al., 2025; Memarian & Doleck, 2024).

To account for this shift, this study adopted the intelligent-TPACK framework (see Figure 1). This move aligns with emerging framework-building work in AI education and educator preparation, as well as with recent attempts to connect TPACK more explicitly to AI adoption and pedagogical intelligence (Black et al., 2024; Chiu, 2025; Liu & Zhong, 2025; Oved & Alt, 2025; Karataş & Ataç, 2025). Considering this perspective, technological knowledge (TK) is expanded to include AI-specific competencies: understanding how machine learning models operate; how they fail (e.g., hallucinations, bias); and how they can be embedded into tasks responsibly. Empirical studies using structural equation modeling have shown that this AI-TK is distinct from general digital literacy and acts as a bottleneck; without it, teachers struggle to develop the pedagogical strategies necessary for AI-augmented environments.

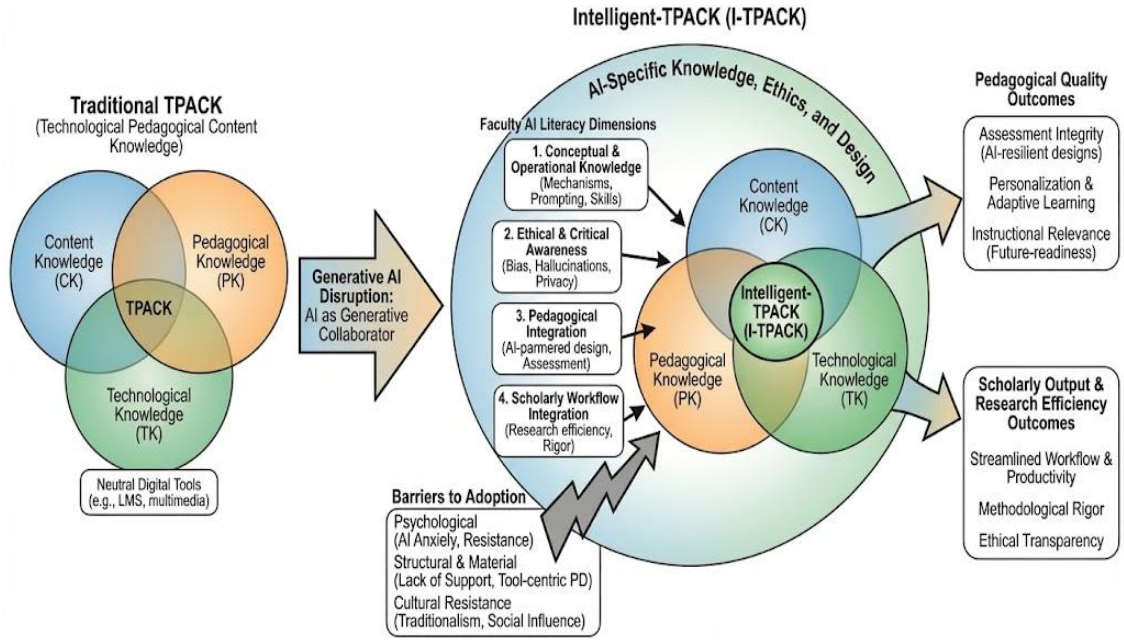

Figure 1: The evolution from traditional TPACK to intelligent-TPACK

In parallel, emerging empirical work suggests that AI-related technological knowledge is not reducible to general digital literacy and may function as a precursor or constraint on teachers' willingness and ability to adopt educational AI tools for teaching purposes (Karataş & Ataç, 2025; Oved & Alt, 2025; Rahimi & Rezvani, 2024). In this perspective, teachers must develop not only technological knowledge in the conventional sense but also AI-specific competencies:

understanding how machine learning models operate; how they can fail (e.g., hallucinations, bias); and how they can be embedded into tasks, assessments, and feedback in ways that are aligned with learning outcomes and ethical norms. Empirical studies using structural equation modeling have shown that AI-TK is empirically distinct from general digital literacy and functions as a bottleneck for the development of AI-oriented pedagogical knowledge. Without this foundational AI-TK, teachers struggle to redesign their teaching in AI-augmented environments, even when they are comfortable with other digital tools.

2.2 Conceptualizing Faculty AI literacy Dimensions

Within this study, faculty AI literacy is conceptualized as a multi-dimensional construct that encompasses:

1. Conceptual and operational knowledge: Understanding the basic mechanisms of large language models and related AI tools, including their probabilistic nature and limitations.
2. Application skills: The ability to use AI tools effectively for teaching- and research-related tasks (e.g., prompting, summarizing, generating exemplars).
3. Ethical and critical awareness: Sensitivity to issues such as bias, privacy, hallucinations, intellectual property, and academic integrity.
4. Pedagogical integration (AI-TPACK): The capacity to redesign curricula, tasks, and assessments so that AI is used as a learning partner, rather than a shortcut, and so that academic standards are preserved or enhanced.

Recent work on pedagogic AI competence argues that these dimensions are not interchangeable; technical or operational proficiency without ethical judgment may encourage uncritical adoption, while conceptual understanding without pedagogical integration is unlikely to transform teaching practice. Accordingly, contemporary educator-focused AI competence frameworks emphasize an integrated model in which conceptual, technical, ethical, and pedagogical capacities are developed together to enable responsible and instructionally meaningful AI use (Celik, 2023; Chiu, 2025; Mikeladze & Meijer, 2024; Zou et al., 2025).

2.3 AI literacy and Pedagogical Quality

The AI competency gap has direct implications for pedagogical quality. Studies on students' adoption of ChatGPT and similar tools indicate that learners are often faster than their instructors in exploring AI's affordances. When faculty do not adapt assessment formats, criteria, and feedback practices to account for such tools, traditional assignments (e.g., generic essays, simple problem sets) become vulnerable to undetected AI-generated content. This undermines the validity of the assessment and can erode trust in grades and qualifications.

Conversely, when teachers develop high levels of AI-TPACK, they can use AI to support more authentic and higher-order learning: for example, by asking students to critique AI-generated outputs, design prompts, or compare human and AI solutions. Evidence from English language teaching and other fields suggests that AI-literate educators are able to reduce routine preparation time, increase personalization, and create richer opportunities for formative feedback.

However, such innovation depends on deep integration, rather than superficial use. Teachers must understand what AI does well, where it fails, and how it can be situated within disciplinary epistemologies.

2.4 AI literacy and Scholarly Productivity

While much of the literature on AI in education has centered on teaching and learning, an expanding strand of scholarship has also examined its implications for academic research. In this area, GenAI tools are increasingly described as useful for streamlining literature exploration, supporting drafting, and assisting with routine analytic or coding tasks, thereby improving research efficiency and potentially lowering linguistic and procedural barriers for some scholars. At the same time, the literature consistently warns that uncritical use may create serious integrity risks, including hallucinated citations, unreliable or fabricated outputs, and inappropriate delegation of authorial work in manuscript preparation (Aithal & Aithal, 2023; Ali, Murray et al., 2024; Ali, Fatemi et al., 2024; Almahasees & Awabdeh, 2024; Baig & Yadegaridehkordi, 2024; Belkina et al., 2025).

Within this dual landscape, AI literacy again becomes a decisive factor. Scholars who understand the capabilities, limits, and risks of generative AI are better positioned to use it for routine or low-level tasks—such as idea generation, language refinement, and preliminary drafting—while retaining human responsibility for conceptual framing, methodological rigor, interpretation, and final authorship. By contrast, uncritical or merely operational use may increase the likelihood of inaccurate outputs, hallucinated references, biased content, and breaches of research integrity or authorship norms. Therefore, a nuanced understanding of AI is essential not only for teaching, but also for safeguarding the integrity, credibility, and quality of scholarly work (Aithal & Aithal, 2023; Ali et al., 2024; Baig & Yadegaridehkordi, 2024; Belkina et al., 2025).

2.5 Barriers to AI-TPACK Development

The persistence of the AI-TPACK chasm can be explained through a combination of psychological, structural, and cultural barriers. At the psychological level, many educators experience AI anxiety, driven by fears of being replaced, of losing control over assessment, or of being exposed as digitally incompetent. Self-efficacy beliefs, shaped by prior experiences with educational technologies, strongly influence willingness to engage with AI. This interpretation is broadly compatible with studies of teacher attitudes, perceptions, and acceptance that document hesitation, uncertainty, and variability in AI readiness among educators (Aghaziarati et al., 2023; Yim & Wegerif, 2024; Hsu & Silalahi, 2024; Kaya & Adıgüzel, 2025).

Structurally, professional development offerings often remain tool-centric, focusing on how to access or operate specific platforms, rather than on how to design AI-aligned pedagogy. This critique is reinforced by recent reviews of AI-focused professional development and educator preparation, which emphasize the need for more conceptually grounded and pedagogy-led forms of training (Brandão et al., 2024; Dogan et al., 2025; Black et al., 2024; David et al., 2025). Time constraints, lack of institutional incentives, and absence of clear policies on AI in

teaching and research further discourage experimentation. Culturally, academic communities that strongly valorize traditional methods may view AI with suspicion, framing early adopters as 'cutting corners', rather than innovating, which discourages adoption among the early and late majority.

Qualitative and perception-focused studies in higher education similarly suggest that AI can be framed simultaneously as support, disruption, or even replacement, which may explain why some faculty remain cautious despite recognizing its utility (Har, 2023; Nguyen, 2023; Haroud & Saqri, 2025). These barriers align with core constructs in the diffusion of innovations theory, such as perceived complexity, compatibility with existing values, and observability of benefits. In many institutions, AI is still perceived as complex, misaligned with academic traditions, and insufficiently legitimized by leadership, leading to irregular and uneven adoption patterns across departments and ranks. This interpretation is also consistent with adoption studies linking uptake to perceived usefulness, available support, and alignment with existing pedagogical beliefs and institutional norms (Cabero-Almenara et al., 2024; Barakat et al., 2024; Molefi et al., 2024).

2.6 Research Gap

Research on AI in education is expanding, but relatively few studies examine in-service university faculty or connect AI literacy to concrete teaching and research outcomes. Fewer still examine both pedagogical practice and scholarly productivity within one model. This expansion is especially visible in recent systematic reviews on curriculum, instruction, assessment, teaching and learning, and broader institutional adoption, although much of this work remains descriptive or distributed across separate subfields (Liang et al., 2025; Phokoye et al., 2025; Salih et al., 2024; Sok & Heng, 2024; Mustafa et al., 2024). Cross-sector reviews also indicate that AI's educational implications are being discussed across school, teacher-education, and higher-education settings, which strengthens the rationale for examining faculty competence as part of a larger systems transition (Crompton et al., 2024; Garcia et al., 2025; David et al., 2025).

Recent studies show cautious optimism toward GenAI alongside concerns about ethics, reliability, and assessment integrity, while also reporting limited formal training and strong demand for discipline-sensitive guidance. Evidence from Arab and Global South higher education remains comparatively limited. This cautious optimism is reflected in studies of stakeholder perceptions and ChatGPT use, which repeatedly report mixed acceptance, perceived utility, unresolved ethical concerns, and a need for stronger literacy and guidance (Hasanein & Sobaih, 2023; Haroud & Saqri, 2025; Kaya & Adıgüzel, 2025; Dube et al., 2024; Dimeli & Kostas, 2025; Mekheimer, 2025; Sposato, 2025; Yang et al., 2024). At the same time, existing regionally relevant evidence is still relatively scattered, with available studies tend to focus on specific stakeholder groups, local perceptions, or discipline-bound cases, rather than integrated institution-level models (Hasanein & Sobaih, 2023; Mekheimer & Fageeh, 2026; Mutanga et al., 2024; Nguyen, 2023; Rahimi & Rezvani, 2024).

This study addresses this gap by empirically linking four dimensions of AI literacy to two critical domains of academic work—teaching and research—while also examining how these relationships vary by rank and discipline. In doing so, it operationalizes the AI-TPACK paradigm as a measurable competency set and uses it to quantify the consequences of AI literacy deficits, rather than merely attitudes toward adoption.

3. Methodology

3.1 Research Design

The study used a cross-sectional survey with a quantitative correlational core and an embedded qualitative component. An online questionnaire measured AI literacy, pedagogical practices quality, and scholarly productivity, plus two optional open-ended prompts. No interviews were conducted. The quantitative strand addressed descriptive levels, associations, and group differences, while the qualitative strand contextualized faculty concerns, constraints, and enabling conditions.

3.2 Context and Participants

The participants were full-time faculty members at a large public university, representing three disciplinary clusters: science, technology, engineering and mathematics (STEM), social sciences, and humanities and arts. A total of 691 complete responses were retained for analysis after data screening.

Academic rank distribution was as follows: lecturer (n = 202, 29.2%), assistant professor (n = 175, 25.3%), associate professor (n = 161, 23.3%), and professor (n = 153, 22.1%). Disciplinary distribution was relatively balanced: STEM (n = 232, 33.6%), social sciences (n = 223, 32.3%), and humanities and arts (n = 236, 34.1%). This spread enabled meaningful comparisons across both rank and discipline in the quantitative analyses.

A substantial proportion of the participants also provided written answers to at least one of the open-ended questions about their use of GenAI and their main concerns or reservations. These narrative comments formed the qualitative dataset used to enrich and interpret the patterns observed in the quantitative results.

3.3 Instruments

The survey included demographic items, four AI literacy subscales, two outcome scales, and two open-ended prompts. The instrument drew on established TPACK measurement work and adapted that tradition to AI-specific competencies conceptualized here as intelligent-TPACK.

Part I: Demographic information

The participants reported academic rank and disciplinary cluster (STEM, social sciences, humanities and arts). This information was used primarily to address RQ3.

Part II: AI literacy dimensions
Informed by the AI-TPACK and AI competence literature and refined through expert review, four AI literacy subscales were developed. Each subscale comprised five items rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), giving each dimension a possible score range of 5–25:

1. Conceptual knowledge (5 items; e.g., understanding how large language models generate text and their limitations).
2. Application skills (5 items; e.g., ability to use AI tools for teaching-related tasks).
3. Ethical and critical awareness (5 items; e.g., recognizing hallucinations, bias, and privacy risks).
4. Pedagogical integration (AI-TPACK) (5 items, e.g., redesigning assessments and tasks in light of AI).

Composite scores were calculated for each dimension and for an overall AI literacy index. Reliability was adequate for conceptual knowledge (alpha = .69), application skills (alpha = .65), and ethical/critical awareness (alpha = .78), while AI-TPACK showed lower reliability (alpha = .59). Accordingly, AI-TPACK results are interpreted cautiously and treated as indicative rather than definitive.

Part III: Pedagogical practices quality and scholarly productivity
The two outcome scales were designed to capture core aspects of faculty work:

1. Pedagogical practices quality (PPQ) captured the extent to which teaching had been adapted for an AI-rich environment, including assessment redesign, guidance on acceptable use, and tasks that require students to critique or improve AI outputs.
2. Scholarly productivity (SP) captured self-reported frequency and quality of recent scholarly outputs across publications, presentations, and fundable proposals (alpha = .65).

A composite output quality index was formed by summing PPQ and SP scores ($\alpha = .90$) and was used in some correlational analyses to capture overall academic performance.

Part IV: Open-ended questions
The two optional open-ended questions invited participants to describe concrete uses of GenAI in teaching or research and to identify their main concerns. These responses were used to contextualize the quantitative findings.

3.4 Data Collection and Analysis
The survey was disseminated electronically through faculty mailing lists and departmental channels. Participation was voluntary and anonymous; informed consent was obtained at the beginning of the survey. Data were exported to a statistical package for quantitative analysis, while open-ended responses were exported to a qualitative analysis environment for thematic coding.

Quantitative data analysis proceeded in four stages:

1. Descriptive statistics (means, standard deviations, ranges) for all AI literacy dimensions and outcome scales, addressing RQ1.

2. Reliability analysis (Cronbach's alpha) for each subscale.
3. Bivariate and multivariate associations, including Pearson correlations among AI literacy dimensions and outcome variables, followed by multiple regression models predicting PPQ and SP from the four AI literacy dimensions (RQ2).
4. Group comparisons, using one-way ANOVAs to examine differences in AI literacy and outcomes by disciplinary cluster and academic rank, followed by post hoc comparisons where relevant (RQ3).

Assumptions of normality, linearity, homoscedasticity, and multicollinearity were checked. While some variables exhibited mild skewness, diagnostics indicated no severe violations; variance inflation factors (VIFs) remained below common cutoffs. The open-ended responses were analyzed using reflexive thematic analysis. Researchers identified recurring ideas, refined them into a shared coding scheme, and grouped them into broader themes used to interpret the quantitative patterns.

4. Results

4.1 Correlations Among AI Literacy and Academic Outcomes

Pearson correlations examined relationships among the four AI literacy dimensions, the composite AI literacy index, and the three outcome variables. As shown in Table 1, all correlations were positive, statistically significant ($p < .001$), and generally large. The four AI literacy dimensions were strongly interrelated and each correlated highly with the composite AI literacy score.

Correlations with pedagogical practices quality ranged from r = .54 to r = .75, and correlations with scholarly productivity ranged from r = .61 to r = .78. Perceived output quality was also strongly related to both outcomes.

Table 1: Intercorrelations among AI literacy dimensions and academic outcomes (N = 691)

Variable	1	2	3	4	5	6	7	8
1. Conceptual Knowledge	—							
2. Application Skills	.81*	—						
3. Ethical/Critical Awareness	.73*	.71*	—					
4.Pedagogical Integration (AI-TPACK)	.65*	.64*	.60*	—				
5. AI Literacy (Composite)	.91*	.90*	.88*	.82*	—			
6. Pedagogical Practices Quality	.75*	.64*	.54*	.71*	.75*	—		
7. Scholarly Productivity	.78*	.69*	.61*	.65*	.78*	.80*	—	
8. Output Quality (Composite)	.80*	.70*	.61*	.72*	.80*	.96*	.94*	—

Note: $p < .001$ for all correlations

4.2 Predicting Pedagogical Practices Quality

A hierarchical regression tested pedagogical practices quality as the criterion variable. Predictors were entered in sequence from foundational to design-oriented competence: conceptual knowledge, pedagogical integration (AI-TPACK), then ethical/critical awareness. Application skills did not add unique

variance once the first two predictors were controlled and was removed for parsimony. Conceptual knowledge explained 56.7% of the variance; adding AI-TPACK increased explained variance to 65%; and adding ethical/critical awareness produced a small final gain. The final model explained 66% of the variance (R2 = .66). Conceptual knowledge was the strongest positive predictor, followed by AI-TPACK, while ethical/critical awareness showed a small negative coefficient that is interpreted cautiously as a possible overlap or suppression effect.

Table 2: Hierarchical regression of AI literacy on pedagogical practices quality (N = 691)

Predictor	*B*	*SE B*	*β*	*t*	*p*
Intercept	−0.02	0.38	—	−0.04	.965
Conceptual Knowledge	0.63	0.04	.57	16.24	< .001
Pedagogical Integration (AI-TPACK)	0.48	0.04	.41	13.44	< .001
Ethical and Critical Awareness	−0.11	0.03	−.12	−3.47	< .001

Note: R^2 = .66, Adjusted R^2 = .66 for the final model

4.3 Predicting Scholarly Productivity

A second hierarchical regression examined self-reported scholarly productivity. Predictors were entered as conceptual knowledge, AI-TPACK, and application skills. Ethical/critical awareness did not add unique variance in preliminary models and was excluded from the final parsimonious model.

Conceptual knowledge explained 60.3% of the variance in scholarly productivity. Adding AI-TPACK raised explained variance to 64%, and application skills added a small but significant increment. In the final model (R2 = .64), conceptual knowledge remained the strongest predictor, followed by AI-TPACK, with application skills contributing a modest positive effect.

Table 3: Hierarchical regression predicting scholarly productivity from AI literacy dimensions (N = 691)

Predictor	*B*	*SE B*	*β*	*t*	*p*
Intercept	1.93	0.35	—	5.59	< .001
Conceptual Knowledge	0.53	0.04	.54	13.37	< .001
Pedagogical Integration (AI-TPACK)	0.24	0.03	.23	7.51	< .001
Application Skills	0.10	0.04	.10	2.51	.012

Note: R^2 = .64, Adjusted R^2 = .64 for the final model

4.4 Group Differences by Discipline and Rank

The analysis of variance (ANOVAs) showed significant differences in AI literacy and academic outcomes by both discipline and academic rank. Discipline effects were consistently larger (partial eta squared = .19-.35) than rank effects (partial eta squared = .02-.06).

Table 4: ANOVA summary for AI literacy and outcomes by discipline (N = 691)

Outcome	F (2, 688)	p	Partial η^2	STEM M (SD)	Social Sciences M (SD)	Humanities & Arts M (SD)
Conceptual Knowledge	174.46	< .001	.34	22.40 (2.45)	18.65 (2.50)	15.32 (2.60)
Application Skills	148.83	< .001	.30	21.85 (2.55)	18.20 (2.45)	15.50 (2.55)
Ethical and Critical Awareness	137.02	< .001	.28	16.50 (2.65)	19.85 (2.40)	21.60 (2.35)
Pedagogical Integration (AI-TPACK)	80.19	< .001	.19	17.80 (2.40)	20.10 (2.25)	16.45 (2.50)
AI Literacy (Composite)	184.79	< .001	.35	78.55 (8.50)	76.80 (8.20)	68.87 (8.85)
Pedagogical Practices Quality	141.81	< .001	.29	18.40 (2.35)	21.15 (2.15)	15.65 (2.45)
Scholarly Productivity	149.08	< .001	.30	20.65 (2.50)	17.90 (2.60)	14.50 (2.40)
Output Quality (Composite)	168.49	< .001	.33	21.45 (2.25)	18.40 (2.40)	14.85 (2.35)

Table 4 indicates clear discipline-based differences. STEM faculty reported the highest conceptual knowledge, application skills, and overall AI literacy, while humanities and arts reported the highest ethical and critical awareness. Social sciences showed the strongest pedagogical integration. All discipline differences were statistically significant with large effect sizes. The same pattern extended to outcomes: social sciences scored highest on pedagogical practices quality, STEM scored highest on scholarly productivity and output quality, and humanities and arts scored lowest on the composite outcome measures. Together, these results support a discipline-based AI-TPACK chasm.

Additional ANOVAs examined differences across academic ranks in the four AI literacy dimensions, the composite literacy score, and the three outcome variables (Table 5).

Table 5: ANOVA summary for AI literacy and outcomes by academic rank (N = 691)

Outcome	F (3, 687)	p	Partial η^2	Lecturer M (SD)	Assistant Prof. M (SD)	Associate Prof. M (SD)	Professor M (SD)
Conceptual Knowledge	4.97	.002	.02	19.30 (2.80)	18.95 (2.75)	18.40 (2.90)	17.65 (3.00)
Application Skills	9.39	< .001	.04	19.65 (2.70)	19.10 (2.65)	18.05 (2.80)	17.20 (2.90)
Ethical and Critical Awareness	15.38	< .001	.06	17.50 (2.80)	18.45 (2.70)	20.25 (2.60)	20.90 (2.55)
Pedagogical Integration (AI-TPACK)	15.83	< .001	.06	16.60 (2.75)	18.80 (2.55)	19.65 (2.45)	18.15 (2.60)
AI Literacy (Composite)	7.81	< .001	.03	73.05 (9.50)	75.30 (9.20)	76.35 (9.60)	73.90 (9.80)
Pedagogical Practices Quality	14.36	< .001	.06	16.85 (2.65)	18.40 (2.50)	19.90 (2.35)	19.10 (2.45)
Scholarly Productivity	6.19	< .001	.03	16.45 (2.85)	18.60 (2.70)	18.10 (2.80)	17.40 (2.90)
Output Quality (Composite)	8.41	< .001	.04	17.90 (2.60)	19.35 (2.45)	18.70 (2.50)	17.45 (2.75)

Academic rank was associated with statistically significant but smaller differences across all variables (all $p < .01$; partial eta squared = .02-.06). Lecturers tended to report stronger basic conceptual and applied skills, professors showed higher ethical and critical awareness, and pedagogical integration was strongest in the middle ranks.

Rank differences in the composite AI literacy score and in the three outcome variables were statistically reliable but modest. Pedagogical practices quality showed one of the largest rank effects, while scholarly productivity and output quality varied more moderately across ranks. Overall, rank differences were most visible in ethical/critical awareness, pedagogical integration, and pedagogical practices quality, whereas differences in basic conceptual knowledge were smaller.

4.5 Summary of Findings

Overall, the quantitative findings support AI literacy as a multi-dimensional capability set. Conceptual knowledge and pedagogical integration showed the strongest associations with pedagogical quality and scholarly productivity, indicating that understanding AI matters most when it is translated into instructional and scholarly practice.

A more nuanced pattern emerged for ethical and critical awareness. Its weaker, and in some models negative, association with pedagogical quality should be interpreted cautiously as a possible suppression or caution effect, rather than a straightforward harmful influence.

Finally, group comparisons point to an uneven institutional landscape. Rank differences were modest, but discipline differences were consistently large: STEM was strongest in conceptual and applied competence, social sciences in pedagogical integration, and humanities and arts in ethical-critical orientation but with lower overall literacy and outcomes. These findings reinforce the need for discipline-sensitive support.

4.6 Qualitative Analysis of Open-Ended Responses

The survey also included optional open-ended prompts about concrete AI uses and main concerns. A substantial subset of the participants provided short written comments that complemented the quantitative trends. These responses were analyzed thematically and yielded five linked themes: opportunity-risk ambivalence, assessment pressure, a gap between innovators and the majority, AI in scholarly work, and calls for stronger institutional support.

4.6.1 Opportunity–risk ambivalence and AI anxiety

Across disciplines and ranks, faculty comments showed clear ambivalence: many viewed AI as a useful assistant for efficiency and feedback, yet also expressed anxiety about control, integrity, and professional identity.

Illustrative comments contrasted enthusiasm about AI-generated explanations with concern about relying on a system that feels opaque or difficult to verify.
This pattern aligns with the quantitative finding that conceptual knowledge is a bottleneck. Faculty with stronger understanding described more constructive experimentation, while those with weaker understanding linked AI to anxiety, moral unease, and avoidance.

4.6.2 Assessment validity under pressure

A second theme was pressure on traditional assessment. Many faculty, especially in writing-intensive fields, described an assessment crisis driven by the ease of AI-assisted student work. Typical comments expressed distrust of take-home writing and a reactive shift toward oral exams, in-class writing, or project work, often without a coherent redesign strategy. Only a minority described deliberate AI-resilient assessment redesign. This supports the quantitative result that AI-TPACK is distinct from general awareness: many faculty recognize the problem but lack design strategies to respond productively.

4.6.3 The AI-TPACK chasm: innovators vs the majority

The qualitative data also illustrated a two-speed pattern. A smaller group of innovators, more common in STEM and senior ranks, described sophisticated AI-augmented teaching practices. Examples included generating alternative problem sets, refining AI outputs, and asking students to compare their own solutions with AI-generated ones. By contrast, many others, especially in humanities and some social sciences, described themselves as struggling to keep up, which reflects the measured AI-TPACK gap. Thus, the chasm is not only statistical; it is also experienced as a social divide between confident adopters and more cautious colleagues.

4.6.4 AI in the ecology of scholarly work

A fourth theme concerned scholarly work. Faculty with higher AI literacy described using AI to brainstorm, refine language, structure drafts, and support routine research tasks, usually alongside manual verification. Others, however, described AI as creating new invisible labor because outputs still require careful checking, rewriting, and source verification. Some of the participants, especially in humanities and social sciences, also worried that heavy reliance on AI could dilute scholarly voice or originality. Again, critical awareness without clear guidance appeared to encourage caution, rather than confident use.

4.6.5 Institutional vacuum and calls for structured support

A final theme was the perception of an institutional vacuum. Faculty often reported limited guidance on acceptable AI use, assessment redesign, and research integrity. Comments repeatedly called for clearer policy, dedicated professional development, discipline-specific exemplars, and recognition of the time needed to redesign courses. Some faculty linked this vacuum directly to the rank and discipline gaps found in the quantitative analysis, with early-career and non-STEM staff describing greater vulnerability. This reinforces the study's central argument: AI literacy and AI-TPACK are shaped not only by individual skill, but also by organizational structures and support.

4.6.6 Synthesis of qualitative and quantitative findings

Overall, the qualitative findings deepen the quantitative results. They show how conceptual grounding and design capacity distinguish confident experimentation from anxious avoidance, and how the measured discipline gaps are experienced in everyday academic work. Considered together, the qualitative evidence suggests that bridging the AI-TPACK chasm requires conceptual grounding, design-based development, and visible institutional support.

5. Discussion

5.1 From TPACK to Intelligent-TPACK and AI-TPACK

The results support the move from general TPACK to intelligent-TPACK and AI-TPACK. Across models, conceptual knowledge and pedagogical integration were the strongest predictors of both pedagogical quality and scholarly productivity. The qualitative findings clarify why this is so: faculty who understood how AI works and how to redesign tasks around it described more confident and purposeful use, whereas those who saw AI as a 'black box' reported minimal or defensive change.

5.2 The Caution Trap: Ethical Awareness Without Design

A notable finding is the small negative association between ethical and critical awareness and pedagogical practices quality in the final regression model. The qualitative data suggest that strong concern, when not paired with AI-TK and AI-TPACK, can translate into restrictive or avoidance-oriented responses. Faculty caught in this caution trap described bans, defensive assessment choices, and uncertainty about losing control, which aligns with prior reports of moral panic and risk-averse responses among educators. The finding does not mean ethical awareness is harmful. Rather, ethics appears most useful when coupled with

concrete design strategies such as AI-resilient tasks, transparency expectations, and explicit reflection on AI use.

5.3 AI Literacy and the Ecology of Scholarly Work

The strong link between AI literacy and scholarly productivity suggests that GenAI is already embedded in academic knowledge work. Faculty with higher AI literacy reported using AI to brainstorm, refine drafts, support translation, and explore analytic options, usually with active fact-checking. At the same time, the qualitative data highlight ambivalence: AI can reduce routine work, but it can also add labor through verification, editing, and source checking.

5.4 Structural Inequalities: Discipline and Rank

The ANOVA findings also show that the AI-TPACK chasm is structured by discipline and rank. STEM faculty were more likely to report advanced experimentation, while many humanities and social sciences faculty positioned themselves as still catching up. These patterns point to a structurally patterned skills gap and underscore the need for differentiated, not one-size-fits-all, support.

5.5 Practical Implications

The converging quantitative and qualitative evidence points to several pressing implications for institutional policy and faculty development; institutions should adopt pedagogy-first GenAI integration by aligning faculty development with assessment redesign, research integrity, and clear, discipline-sensitive guidance. Support should explicitly connect conceptual knowledge to hands-on AI-TPACK and provide targeted mentoring and exemplars for non-STEM and early-career staff.

6. Limitations and Future Research

This study has four main limitations. First, its cross-sectional, self-report design does not support causal inference and may inflate associations. Second, overlap among predictors may contribute to suppression patterns. Third, the AI-TPACK subscale showed relatively low reliability and needs refinement. Fourth, the findings are anchored in one institutional setting, so cross-context comparison is still needed.

These limits sharpen the policy message: closing the AI competency gap is not just a technical issue but a strategic quality issue. As AI becomes embedded in academic work, universities need clear acceptable-use rules, assessment integrity guidance, and pedagogy-first capacity building that combines ethical judgment, conceptual understanding, and practical design skills. Implementation also has resource implications. Institutions need time, staffing, and design support to sustain this work, and support should be differentiated across career stages so that both early-career and senior faculty can engage confidently and responsibly.

Future research should use longitudinal and comparative designs, triangulate self-reports with behavioral indicators, and examine how students perceive fairness, feedback quality, and transparency in AI-mediated teaching.

Overall, closing the AI-TPACK chasm requires more than awareness or tool access. It requires coordinated policy, resources, and professional learning that support responsible AI integration in teaching and research.

7. Conclusion

This study advances scholarship on GenAI in higher education by linking faculty AI literacy to measurable institutional outcomes, rather than linking it to adoption intentions alone. Modelling AI literacy as a four-dimensional construct, it shows that conceptual knowledge and pedagogical integration are the most consistent predictors of pedagogical practices quality and scholarly productivity. The mixed-methods findings also explain why risk awareness can coincide with weaker pedagogical change: when ethical concern is not paired with practical design strategies, faculty may respond defensively through bans, avoidance, or AI-vulnerable assessment choices.

In addition, discipline and career-stage disparities lead to an emerging two-speed university in which some staff can use GenAI productively while others struggle under policy ambiguity and unequal access to support. Universities should therefore move beyond tool-centric workshops and invest in design-based, discipline-sensitive development that integrates conceptual, ethical, and pedagogical competencies.

8. Declarations

8.1 Funding

The authors extend their appreciation to Prince Sattam bin Abdulaziz University for funding this research work through the project number (PSAU/2025/01/35593).

8.2 Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

8.3 Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Ethical approval was obtained from the Research Ethics Committee at Prince Sattam bin Abdulaziz University (Approval No.: PSAU/FoE/2025/01/35593). Participation was voluntary and anonymous, and informed consent was obtained electronically from all participants prior to data collection.

8.4 Consent for Publication

Not applicable. The manuscript does not contain any individual person's data in any form (including any individual details, images, or videos).

8.5 Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available due to institutional regulations and the need to protect participant confidentiality but are available from the corresponding author on reasonable request and subject to the approval of the relevant institutional authorities.

8.6 Authors' Contributions

Fatimah Ali ALhuraybi led the conceptualization of the study, coordinated data collection, and contributed to the interpretation of results. Mohammed Rahmath designed and implemented the quantitative analysis and contributed to instrument development and data visualization. Mohamed Sayed Abdellatif contributed to study design, oversaw the ethical procedures, and supported the interpretation of psychological and pedagogical constructs. Mohamed Mekheimer led the mixed-methods design, directed the qualitative analysis, and drafted and critically revised the manuscript for important intellectual content. Walid Abdelhalim contributed to the theoretical framing, contextualized the findings within higher education policy and faculty development, and assisted in revising the manuscript.

Author team rationale: This study required an interdisciplinary team to ensure methodological and subject-matter rigor. The authors contributed complementary expertise in higher education policy and faculty development, psychometrics and quantitative modelling, qualitative analysis of open-ended responses, AI-in-education scholarship, and manuscript synthesis and APA 7th edition style compliance, which together exceeded what could reasonably be assured by four or fewer authors. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

9. Acknowledgements

The authors thank Prince Sattam bin Abdulaziz University for supporting this work (project number PSAU/2025/01/35593). In preparing the manuscript, the authors used generative AI tools only for limited language polishing and readability suggestions; all substantive content, interpretations, and responsibility for accuracy remain with the authors.

10. References

Aghaziarati, A., Nejatifar, S., & Abedi, A. (2023). Artificial intelligence in education: Investigating teacher attitudes. *AI and Tech in Behavioral and Social Sciences*, *1*(1), 59–73. https://doi.org/10.61838/kman.aitech.1.1.6

Aithal, P. S., & Aithal, S. (2023). Application of ChatGPT in higher education and research: A futuristic analysis. *International Journal of Applied Engineering and Management Letters*, *7*(1), 282–301. https://doi.org/10.47992/IJAEML.2581.7000.0193

Albadarin, Y., Saqr, M., Pope, N., & Tukiainen, M. (2024). A systematic literature review of empirical research on ChatGPT in education. *Discover Education*, *3*(1), Article 12. https://doi.org/10.1007/s44217-024-00138-2

Ali, D., Fatemi, Y., Boskabadi, E., Nikfar, M., & Ugwuoke, J. (2024). ChatGPT in teaching and learning: A systematic review. *Education Sciences*, *14*(6), 643. https://doi.org/10.3390/educsci14060643

Ali, O., Murray, P. A., Momin, M., & Dwivedi, Y. K. (2024). The effects of artificial intelligence applications in educational settings: Challenges and strategies.

Technological Forecasting and Social Change, *199*, Article 123076. https://doi.org/10.1016/j.techfore.2023.123076

Almahasees, Z., & Awabdeh, A. A. (2024). ChatGPT and higher education: A pathway to unprecedented progress. *Journal of Higher Education Theory and Practice*, *24*(5), 23–37. https://doi.org/10.33423/jhetp.v24i5.7004

Baig, M. I., & Yadegaridehkordi, E. (2024). ChatGPT in higher education: A systematic literature review and research challenges. *International Journal of Educational Research*, *123*, Article 102411. https://doi.org/10.1016/j.ijer.2024.102411

Barakat, M., Salim, N. A., & Sallam, M. (2024). *Perspectives of university educators regarding ChatGPT: A validation study based on the technology acceptance model*. Research Square. https://doi.org/10.21203/rs.3.rs-2895792/v1

Belkina, M., Daniel, S., Nikolic, S., & Haque, R. (2025). Implementing generative AI (GenAI) in higher education: A systematic review of case studies. *Computers and Education: Artificial Intelligence*, *6*, Article 100232. https://doi.org/10.1016/j.caeai.2024.100232

Beri, N., & Sharma, L. (2021). Development of TPACK for teacher-educators: A technological pedagogical content knowledge scale. *Linguistics and Culture Review*, *5*(S1), 1397–1418. https://doi.org/10.21744/lingcure.v5nS1.1646

Black, N. B., George, S., Eguchi, A., & Dempsey, J. C. (2024). A framework for approaching AI education in educator preparation programs. *Proceedings of the AAAI Conference on Artificial Intelligence*, *38*(21), 21513–21521. https://doi.org/10.1609/aaai.v38i21.30351

Brandão, A., Pedro, L., & Zagalo, N. (2024). Teacher professional development for a future with generative artificial intelligence: An integrative literature review. *Digital Education Review*, *45*, 151–167. https://doi.org/10.1344/der.2024.45.151-167

Cabero-Almenara, J., Palacios-Rodríguez, A., & Llorente-Cejudo, C. (2024). The impact of pedagogical beliefs on the adoption of generative AI in higher education: Predictive model from UTAUT2. *Frontiers in Artificial Intelligence*, *7*, Article 1378210. https://doi.org/10.3389/frai.2024.1378210

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*, Article 107468. https://doi.org/10.1016/j.chb.2022.107468

Chichekian, T., & Benteux, B. (2022). The potential of learning with (and not from) artificial intelligence in education. *Frontiers in Artificial Intelligence*, *5*, Article 879895. https://doi.org/10.3389/frai.2022.879895

Chiu, T. K. F. (2025). Developing intelligent-TPACK (I-TPACK) framework from unpacking AI literacy and competency: Implementation strategies and future research direction. *Interactive Learning Environments*. Advance online publication. https://doi.org/10.1080/10494820.2024.2446892

Crompton, H., Jones, M. V., & Burke, D. (2024). Affordances and challenges of artificial intelligence in K–12 education: A systematic review. *Journal of Research on Technology in Education*, *56*(3), 395–420. https://doi.org/10.1080/15391523.2023.2293579

David, O. V. H., de María, S. C. Y., & Angel, S. M. (2025). Educational technology in teacher training: A systematic review of competencies, skills, models, and methods. *Education Sciences*, *15*(6), 656. https://doi.org/10.3390/educsci15060656

Díaz, B., & Nussbaum, M. (2024). Artificial intelligence for teaching and learning in schools: The need for pedagogical intelligence. *Computers & Education*, *208*, Article 104846. https://doi.org/10.1016/j.compedu.2023.104846

Dimeli, M., & Kostas, A. (2025). The role of ChatGPT in education: Applications, challenges, and insights from a systematic review. *Journal of Information Technology Education: Research*, *24*, 1–30. https://doi.org/10.28945/5422

Dogan, S., Nalbantoglu, U. Y., Celik, I., & Agacli Dogan, N. (2025). Artificial intelligence professional development: A systematic review of TPACK, designs, and effects for teacher learning. *Professional Development in Education*, *51*(3), 519–546. https://doi.org/10.1080/19415257.2025.2454457

Dube, S., Dube, S., Ndlovu, B. M., & Maguraushe, K. (2024). Students' perceptions of ChatGPT in education: A rapid systematic literature review. *Science and Information*, *13*(3), 181–198. https://doi.org/10.29268/stinfo.2024.13.3.181

Fabian, A., Backfisch, I., Kirchner, K., & Lachner, A. (2024). A systematic review and meta-analysis on TPACK-based interventions from a perspective of knowledge integration. *Computers and Education Open*, *7*, Article 100200. https://doi.org/10.1016/j.caeo.2024.100200

Fuentes, J. O., Clorion, F. D. D., & Abequibel, B. (2024). Understanding the attitude of teacher education students toward utilizing ChatGPT as a learning tool: A quantitative analysis. In S. B. Thorsteinsson & M. Singh (Eds.), *Digital transformation: Technology innovation for sustainable development*. Springer.

Garcia, O. A., García, M. C. R., & Paez, R. (2025). Perceptions, strategies, and challenges of teachers in the integration of artificial intelligence in primary education: A systematic review. *Journal of Information Technology Education: Research*, *24*, 1–29. https://doi.org/10.28945/5309

Garzón, J., Patiño, E., & Marulanda, C. (2025). Systematic review of artificial intelligence in education: Trends, benefits, and challenges. *Multimodal Technologies and Interaction*, *9*(1), 13. https://doi.org/10.3390/mti9010013

Har, F. (2023). Teaching English as a second language in the midst of a paradigm shift: An exploration of students' and teachers' perception of ChatGPT. In A. W. B. TSO, W. W. L. Chan, Steven Kwan Keung NG, Tiffany Shurui BAI, Noble Po Kan LO (Eds.), *Critical reflections on ICT and education: Selected papers from the HKAECT 2023 international conference* (pp. 21–35). Springer. https://doi.org/10.1007/978-981-99-7559-4_2

Haroud, S., & Saqri, N. (2025). Generative AI in higher education: Teachers' and students' perspectives on support, replacement, and digital literacy. *Education Sciences*, *15*(2), 85. https://doi.org/10.3390/educsci15020085

Harris, J. B. (2016). In-service teachers' TPACK development: Trends, models, and trajectories. In M. C. Herring, M. J. Koehler, & P. Mishra (Eds.), *Handbook of technological pedagogical content knowledge (TPACK) for educators* (2nd ed., pp. 191–206). Routledge. https://doi.org/10.4324/9781315771328

Harris, J. B., Phillips, M., & Koehler, M. J. (2017). TPCK/TPACK research and development: Past, present, and future directions. *Australasian Journal of Educational Technology*, *33*(3), 1–8. https://doi.org/10.14742/ajet.3907

Hasanein, A. M., & Sobaih, A. E. E. (2023). Drivers and consequences of ChatGPT use in higher education: Key stakeholder perspectives. *European Journal of Investigation in Health, Psychology and Education*, *13*(11), 2505–2525. https://doi.org/10.3390/ejihpe13110181

Herring, M. C., Koehler, M. J., & Mishra, P. (Eds.). (2016). *Handbook of technological pedagogical content knowledge (TPACK) for educators* (2nd ed.). Routledge. https://doi.org/10.4324/9781315771328

Hsu, W. L., & Silalahi, A. D. K. (2024). Exploring the paradoxical use of ChatGPT in education: Analyzing benefits, risks, and coping strategies through integrated UTAUT and PMT theories. *Computers and Education: Artificial Intelligence*, *6*, Article 100239. https://doi.org/10.1016/j.caeai.2024.100239

Ifenthaler, D., Majumdar, R., Gorissen, P., & Judge, M. (2024). Artificial intelligence in education: Implications for policymakers, researchers, and practitioners. *Technology, Knowledge and Learning, 29*(1), 1–12. https://doi.org/10.1007/s10758-023-09687-9

Karataş, F., & Ataç, B. A. (2025). When TPACK meets artificial intelligence: Analyzing TPACK and AI-TPACK components through structural equation modelling. *Education and Information Technologies*, *30*, 13164. https://doi.org/10.1007/s10639-024-13164-2

Kaya, M., & Adıgüzel, T. (2025). Exploring the acceptance of ChatGPT in higher education: A comprehensive quantitative study of university students and faculty. *Frontiers in Education*, *10*, Article 1652292. https://doi.org/10.3389/feduc.2025.1652292

Kazimova, D., Tazhigulova, G., Shraimanova, G., & Sharzadin, A. (2025). Transforming university education with AI: A systematic review of technologies, applications, and implications. *International Journal of Engineering Pedagogy*, *15*(1). https://doi.org/10.3991/ijep.v15i1.50773

Khine, M. S., Ali, N., & Afari, E. (2017). Exploring relationships among TPACK constructs and ICT achievement among trainee teachers. *Education and Information Technologies*, *22*(4), 1605–1621. https://doi.org/10.1007/s10639-016-9507-9

Kopcha, T. J., Ottenbreit-Leftwich, A., & Jung, J. (2014). Examining the TPACK framework through the convergent and discriminant validity of two measures. *Computers & Education*, *78*, 87–96. https://doi.org/10.1016/j.compedu.2014.05.003

Lachner, A., Fabian, A., Franke, U., Preiß, J., & Jacob, L. (2021). Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. *Computers & Education*, *174*, Article 104304. https://doi.org/10.1016/j.compedu.2021.104304

Liang, J., Stephens, J. M., & Brown, G. T. L. (2025). A systematic review of the early impact of artificial intelligence on higher education curriculum, instruction, and assessment. *Frontiers in Education*, *10*, Article 1522841. https://doi.org/10.3389/feduc.2025.1522841

Liu, X., & Zhong, B. (2025). Integrating generative artificial intelligence into student learning: A systematic review from a TPACK perspective. *Educational Research Review*, *39*, Article 100741. https://doi.org/10.1016/j.edurev.2025.100741

Ma, Q., Crosthwaite, P., Sun, D., & Zou, D. (2024). Exploring ChatGPT literacy in language education: A global perspective and comprehensive approach. *Computers and Education: Artificial Intelligence*, *6*, Article 100278. https://doi.org/10.1016/j.caeai.2024.100278

Ma, T. (2025). Systematically visualizing ChatGPT used in higher education: Publication trend, disciplinary domains, research themes, adoption and acceptance. *Computers and Education: Artificial Intelligence*, *7*, Article 100336. https://doi.org/10.1016/j.caeai.2024.100336

Marengo, A., Pagano, A., & Pange, J. (2024). The educational value of artificial intelligence in higher education: A 10-year systematic literature review. *Smart Learning Environments*, *11*, Article 40. https://doi.org/10.1186/s40561-024-00283-7

Mekheimer, M. (2025). Generative AI-assisted feedback and EFL writing: A study on proficiency, revision frequency and writing quality. *Discover Education*, *4*, 170. https://doi.org/10.1007/s44217-025-00602-7

Mekheimer, M., & Abdelhalim, W. (2026). Beyond translation: A quantitative study on foreign language proficiency, academic identity, and dissonance among educational researchers. *Asian-Pacific Journal of Second and Foreign Language Education*, *11*, 9. https://doi.org/10.1186/s40862-025-00378-1

Mekheimer, M., & Fageeh, A. (2026). Motivation, ethics, and trust: A data-informed analysis of generative AI's impact on EFL students. *Journal of Teaching and Learning with Technology*, *14*(1). https://scholarworks.iu.edu/journals/index.php/jotlt/article/view/41807

Memarian, B., & Doleck, T. (2024). Teaching and learning artificial intelligence: Insights from literature. *Education and Information Technologies*, *29*, 10225–10255. https://doi.org/10.1007/s10639-024-12679-y

Mikeladze, T., & Meijer, P. C. (2024). A comprehensive exploration of artificial intelligence competence frameworks for educators: A critical review. *European Journal of Education*, *59*(3), e12677. https://doi.org/10.1111/ejed.12677

Mohammed, A. T., Velander, J., & Milrad, M. (2024). A retrospective analysis of artificial intelligence in education (AIEd) studies: Perspectives, learning theories, challenges, and emerging opportunities. In *Radical solutions for artificial intelligence in education*. Springer. https://doi.org/10.1007/978-981-97-8638-1_9

Molefi, R. R., Ayanwale, M. A., & Kurata, L. (2024). Do in-service teachers accept artificial intelligence-driven technology? The mediating role of school support and resources. *Computers and Education Open*, *5*, Article 100166. https://doi.org/10.1016/j.caeo.2024.100166

Monib, W. K., Qazi, A., & Mahmud, M. M. (2025). Exploring learners' experiences and perceptions of ChatGPT as a learning tool in higher education. *Education and Information Technologies*, *30*, 2297–2327. https://doi.org/10.1007/s10639-024-13065-4

Mustafa, M. Y., Tlili, A., Lampropoulos, G., & Huang, R. (2024). A systematic review of literature reviews on artificial intelligence in education (AIEd): A roadmap to a future research agenda. *Smart Learning Environments*, *11*, Article 8. https://doi.org/10.1186/s40561-024-00278-4

Mutanga, M. B., Jugoo, V., & Adefemi, K. O. (2024). Lecturers' perceptions on the integration of artificial intelligence tools into teaching practice. *Trends in Higher Education*, *3*(4), 1121–1133. https://doi.org/10.3390/higheredu3040066

Nguyen, T. C. (2023). University teachers' perceptions of using ChatGPT in language teaching and assessment. *Proceedings of the Asia CALL International Conference*, 4, 116–128. https://doi.org/10.54855/paic.2349

Niloy, A. C., Bari, M. A., Sultana, J., & Chowdhury, R. (2024). Why do students use ChatGPT? Answering through a triangulation approach. *Computers and Education: Artificial Intelligence*, *6*, Article 100296. https://doi.org/10.1016/j.caeai.2024.100296

Onal, S., & Kulavuz-Onal, D. (2025). Patterns of ChatGPT usage and perceived benefits on academic performance across disciplines: Insights from a survey of higher education students in the United States. *Journal of Educational Computing Research*, *63*(3), 503–534. https://doi.org/10.1177/07356331241255969

Oved, O., & Alt, D. (2025). Teachers' technological pedagogical content knowledge (TPACK) as a precursor to their perceived adopting of educational AI tools for teaching purposes. *Education and Information Technologies*. Advance online publication. https://doi.org/10.1007/s10639-024-11832-2

Pamuk, S. (2012). Understanding preservice teachers' technology use through TPACK framework. *Journal of Computer Assisted Learning*, *28*(5), 425–439. https://doi.org/10.1111/j.1365-2729.2011.00447.x

Pamuk, S., Ergun, M., Cakir, R., & Yilmaz, H. B. (2015). Exploring relationships among TPACK components and development of the TPACK instrument. *Education and Information Technologies*, *20*(4), 241–263. https://doi.org/10.1007/s10639-013-9278-4

Phokoye, S. P., Dlamini, S., Mthalane, P. P., & Luthuli, M. (2025). A comprehensive review of ChatGPT in teaching and learning within higher education. *Informatics*, *12*(2), Article 24. https://doi.org/10.3390/informatics12020024

Rahimi, S., & Rezvani, R. (2024). Enhancing English instructors' TPACK through AI: Exploring its role in language education. *Iranian Journal of English for Academic Purposes*, *3*(1), 120–147. https://doi.org/10.30498/IJEAP.2024.425659.1262

Redmond, P., & Lock, J. (2019). Secondary pre-service teachers' perceptions of technological pedagogical content knowledge (TPACK): What do they really

think? *Australasian Journal of Educational Technology*, *35*(3), 45–59. https://doi.org/10.14742/ajet.4214

Salih, S., Husain, O., Hamdan, M., & Abdelsalam, S. (2024). Transforming education with AI: A systematic review of ChatGPT's role in learning, academic practices, and institutional adoption. *Results in Engineering*, *25*, Article 103837. https://doi.org/10.1016/j.rineng.2024.103837

Sok, S., & Heng, K. (2024). Opportunities, challenges, and strategies for using ChatGPT in higher education: A literature review. *Journal of Digital Educational Technology*, *4*(1), Article ep2401. https://doi.org/10.30935/jdet/14027

Sposato, M. (2025). A call for caution and evidence-based research on the impact of artificial intelligence in education. *Quality Education for All*, *2*(1), 160–172. https://doi.org/10.1108/QEA-09-2024-0087

Yang, X., Wang, Q., & Lyu, J. (2024). Assessing ChatGPT's educational capabilities and application potential. *ECNU Review of Education*, *7*(3), 699–713. https://doi.org/10.1177/20965311231210006

Yim, I. H. Y., & Wegerif, R. (2024). Teachers' perceptions, attitudes, and acceptance of artificial intelligence (AI) educational learning tools: An exploratory study on AI literacy for young students. *Futures in Education Research*, *3*(1), e65. https://doi.org/10.1002/fer3.65

Yurdakul, I. K., Odabasi, H. F., Kilicer, K., Coklar, A. N., Birinci, G., & Kurt, A. A. (2012). The development, validity and reliability of TPACK-deep: A technological pedagogical content knowledge scale. *Computers & Education*, *58*(3), 964–977. https://doi.org/10.1016/j.compedu.2011.10.012

Zakaria, N., & Hashim, H. (2024). Shaping the future of education: Conceptualising pre-service teachers' perspectives on artificial intelligence (AI) integration. *International Journal of Academic Research in Business and Social Sciences*, *14*(5), 713–727. https://doi.org/10.6007/IJARBSS/v14-i5/21584

Zhang, W., & Tang, J. (2021). Teachers' TPACK development: A review of literature. *Open Journal of Social Sciences*, *9*(7), 367–380. https://doi.org/10.4236/jss.2021.97027

Zou, D., Huang, X., Kohnke, L., Chen, X., & Cheng, G. (2022). A bibliometric analysis of the trends and research topics of empirical research on TPACK. *Education and Information Technologies*, *27*(8), 10585–10609. https://doi.org/10.1007/s10639-022-10991-z

Zou, D., Xie, H., & Kohnke, L. (2025). Navigating the future: Establishing a framework for educators' pedagogic artificial intelligence competence. *European Journal of Education*, *60*(2), e14039. https://doi.org/10.1111/ejed.14039