

Teachers' perceptions of ChatGPT support across TPACK domains: A cross-sectional survey in UAE schools

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Abstract

The purpose of this study is to examine teachers' perceptions of ChatGPT support for instructional practices from the technological pedagogical content knowledge (TPACK) framework perspective. A quantitative cross-sectional survey design was employed, with data collected from 109 in-service teachers in the United Arab Emirates using a structured questionnaire measuring seven TPACK knowledge domains. Descriptive and inferential statistical analyses were employed to examine teachers' perceptions of ChatGPT support across the TPACK domains and differences associated with demographic variables. The results indicate that teachers perceived ChatGPT as providing positive support across all TPACK domains. Content knowledge (CK) received the highest score, particularly for curriculum development, lesson planning, and instructional content preparation, whereas technological knowledge (TK) received the lowest score. A Wilcoxon signed-rank test indicated a statistically significant difference between perceived ChatGPT support for CK and TK. No statistically significant differences were found in teachers' perceptions of gender, teaching experience, or academic qualification. The findings suggest that ChatGPT is perceived as a useful instructional support tool across TPACK-related practices, while effective and responsible use requires stronger artificial intelligence (AI) literacy and technological competence. The study recommends professional development focusing on prompt design, critical evaluation of AI-generated content, bias awareness, privacy protection, and ethical AI use.

Keywords: artificial intelligence, ChatGPT, in-service teachers, TPACK, generative AI, teacher AI literacy

INTRODUCTION

The rapid development of artificial intelligence (AI) technology has brought revolutionary changes to many fields, one of which is the education sector (Baidoo-Anu & Ansah, 2023; Firat, 2023; Sapci & Sapci, 2020). AI technology has radically transformed the teaching and learning process, providing new opportunities to improve teaching approaches and engage students in better ways (Crompton & Burke, 2023). The use of AI-based tools, especially generative AI (GenAI) tools such as ChatGPT, has achieved tremendous recognition in the education sector for its ability to generate information, provide instant responses, personalized learning, and create unique learning experiences (Sapci & Sapci, 2020;

Zawacki-Richter et al., 2019). Given the dynamic development rate of AI technology, educators are increasingly incorporating AI-based technologies into their practices to improve the quality of the curriculum, assessment, and interactive learning process (Holmes et al., 2019). However, the pedagogical implications of adopting AI-based technologies, especially in relation to how it affects the ability of educators to integrate the content, the technology, and the pedagogy, have not yet received sufficient research attention.

Technological pedagogical content knowledge (TPACK), as a conceptual framework, is the most prominent approach to understanding the integration of technology in education, focusing on the interplay between technological knowledge (TK), pedagogical

Contribution to the literature

- This study examines teachers' perceptions of ChatGPT support across the seven TPACK domains in United Arab Emirates (UAE) schools. It identifies CK as the strongest and TK as the weakest perceived area of support.
- The findings highlight the importance of AI literacy, ethical AI use, and critical evaluation in teachers' professional development.
- The findings contribute empirical evidence to the emerging discussion of how TPACK can be understood in the context of GenAI.

knowledge (PK), and content knowledge (CK) (Koehler et al., 2013). To provide better learning experiences in the age of technology, educators need to develop skills in these three areas. Using AI tools such as ChatGPT can help educators in developing their technological pedagogical knowledge (TPK), technological content knowledge (TCK), and TPACK in general, as it can provide dynamic instructional support, develop relevant instructional content, and generate innovative technological applications for teaching (Schmid et al., 2021). It remains unclear how in-service teachers can effectively integrate AI tools into their instructional practices and enhance teaching and learning outcomes. The educational sector presents both opportunities and challenges for the adoption of ChatGPT. On the positive side, it offers instant access to enormous knowledge banks, aids lesson planning, and facilitates interactive learning through adaptive questioning and computerized feedback (Mollick & Mollick, 2023). ChatGPT can be leveraged by educators for generating discussion questions, providing tailored-up explanation, as well as for promoting participation through AI-enabled simulation.

Despite its considerable potential, several studies have highlighted important challenges associated with the educational use of ChatGPT (Bender et al., 202; Cardona et al., 2023; Miao & Holmes, 2023; Ng et al., 2021). These include the possibility of generating inaccurate or fabricated information, algorithmic bias, concerns regarding data privacy, and the risk of overreliance on AI-generated content, which may reduce students' critical thinking and independent problem-solving skills (Kasneci et al., 2023; Tlili et al., 2023). Consequently, the effective integration of ChatGPT requires appropriate pedagogical guidance, ethical considerations, and continuous teacher professional development (Roll & Wylie, 2016).

Although previous studies have examined the educational applications of ChatGPT, most have focused on student learning, academic writing, or the general adoption of AI technologies in education. Limited research has investigated how teachers perceive ChatGPT as supporting each knowledge domain of the TPACK framework among in-service teachers. Furthermore, few studies have examined the disparity between teachers' strong perceptions of ChatGPT for

instructional content development and their comparatively lower TK required for effective and ethical AI integration. By examining all seven TPACK domains, this study contributes to the emerging AI-TPACK literature and extends current understanding of teachers' AI literacy and GenAI-supported instructional competence.

Aim of the Study

This study aims to examine teachers' perceptions of ChatGPT support for in-service teachers' instructional practices through the lens of the TPACK framework. Specifically, the study seeks to examine how teachers perceive ChatGPT as supporting the integration of content, pedagogy, and technology in lesson planning, classroom implementation, and formative assessment. In addition, the study examines teachers' perceptions of ChatGPT support for recommending context-appropriate technological tools, facilitating interactive learning strategies, and informing teachers' instructional decision-making processes.

Significance of the Study

This research contributes to the field of AI-in-education research by empirically examining teachers' perceptions of ChatGPT support across the TPACK framework.

Research Questions

Guided by the objectives of this study, the following research questions (RQs) were formulated to examine teachers' perceptions of ChatGPT support for the integration of content, pedagogy, and technology within the TPACK framework.

Main research question

To what extent do teachers perceive ChatGPT as supporting their integration of content, pedagogy, and technology as conceptualized in the TPACK framework?

Sub-research questions

- RQ1:** What is the level of in-service teachers' TK related to the use of ChatGPT?

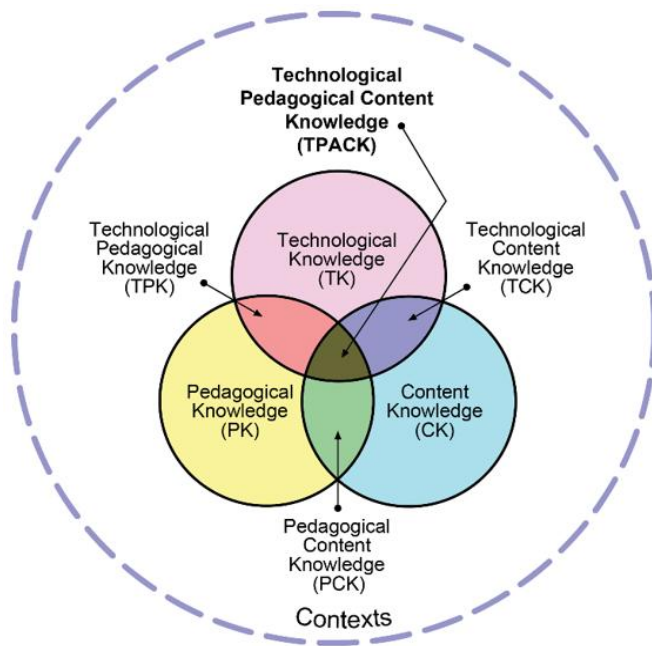


Figure 1. TPACK framework. (reproduced by permission of the publisher, © 2012 by tpack.org)

- RQ2:** To what extent do teachers perceive ChatGPT as supporting their PK, including lesson planning, student engagement, and formative assessment?
- RQ3:** How effectively do teachers perceive ChatGPT as supporting them in developing accurate, reliable, and curriculum-aligned instructional content (CK)?
- RQ4:** How do teachers perceive ChatGPT as supporting their pedagogical content knowledge (PCK) in designing meaningful, engaging, and reflective learning experiences?
- RQ5:** To what extent do teachers perceive ChatGPT as supporting TPK in their teaching practices?
- RQ6:** To what extent do teachers perceive ChatGPT as supporting TCK in their teaching practices?
- RQ7:** To what degree do teachers perceive ChatGPT as supporting the comprehensive integration of TPACK in their instructional practices?
- RQ8:** Are there significant differences in teachers' perceptions of ChatGPT support for TPACK-related practices based on demographic variables such as gender, teaching experience, and academic qualification?

THEORETICAL FRAMEWORK

The theoretical framework of this study is based on the TPACK framework. The TPACK framework explains how teachers integrate technology, pedagogy, and subject content in teaching and learning processes. The concept was developed by Mishra and Koehler (2006) as an extension of PCK introduced by Shulman (1986). The framework provides a comprehensive model

that explains how effective teaching requires the interaction of TK, PK, and CK.

The increasing use of AI tools such as ChatGPT has created new opportunities for teachers to enhance instructional design, lesson planning, and student engagement (Dogan, 2025). Within this context, the TPACK framework provides an appropriate theoretical foundation for examining how AI technologies support teachers in integrating technology with pedagogy and subject content (Niess, 2011). **Figure 1** depicts the TPACK framework.

Technological Knowledge

TK refers to teachers understanding digital technologies and their ability to use them effectively in educational contexts. This construct refers to teachers' knowledge of the technological tools, digital technologies, and emerging technologies that are used in pedagogy (Mishra & Koehler, 2006). In the current research, TK refers to teachers' knowledge of ChatGPT, their ability to harness the potential of ChatGPT for pedagogical purposes, and their knowledge of the ethical implications, data privacy, and technological issues of AI tools. Past research has emphasized the importance of teachers' TK as a significant factor in the integration of technology into the educational environment (Akram et al., 2022; Niess, 2011; Siyam et al., 2025).

Pedagogical Knowledge

On the other hand, PK refers to the strategies and ways by which a teacher can facilitate the construction of knowledge. This includes the ways by which a teacher can design learning strategies for the students so that their engagement can be maximized and the construction of knowledge can be effectively achieved (Koehler & Mishra, 2009). In this study, PK refers to the ways by which a teacher can effectively incorporate the use of ChatGPT into their teaching practices, lesson planning, and instructional strategies to improve student participation and learning outcomes.

Content Knowledge

CK refers to the knowledge base of the subject matter for which the teacher is responsible for teaching. This includes a comprehensive understanding of the concepts, theories, and principles unique to a specific subject matter (Shulman, 1986). In the present study, CK is examined through the role played by ChatGPT in helping the teacher design the content of the lesson according to the curriculum requirements and the needs of the students. Instructional strategies need to be complemented by a strong CK base.

Pedagogical Content Knowledge

PCK is a term used to illustrate the intersection of methodology and subject knowledge. It refers to a teacher's ability to "transform subject matter into representations which make it accessible and meaningful to others" (Shulman, 1987). PCK, as it applies to this research, is concerned with the role of ChatGPT in helping teachers design lesson plans that foster learning, engagement, creativity, and critical thinking among students. Shulman (1987) stated, "A capacity to represent subject matter in ways that make it accessible and meaningful to others is at the core of what effective teaching seems to entail."

Technological Pedagogical Knowledge

TPK refers to the understanding of how teaching strategies change when technology is integrated into learning environments. It involves knowledge of how digital tools can support different instructional methods (Mishra & Koehler 2006). In this study, TPK focuses on the role of ChatGPT in suggesting technological tools, supporting interactive learning activities, and enhancing teaching strategies that encourage student engagement and participation.

Technological Content Knowledge

TCK describes the relationship between technology and subject matter. It refers to teachers' ability to use technological tools to represent and explain subject content more effectively (Koehler & Mishra 2009). In this research, TCK is explored through the ability of ChatGPT to recommend technologies that support the explanation of complex concepts, organize subject information, and improve students understanding of course content.

Technological Pedagogical Content Knowledge

TPACK represents the full integration of technology pedagogy and subject content in teaching practice. It reflects teachers' ability to combine these three domains effectively to design meaningful and technology-enhanced learning experiences (Koehler & Mishra 2009, Lu & Chen, 2025). In this study, the TPACK framework is used to analyze how ChatGPT supports teachers in integrating technological tools with teaching strategies and curriculum content to improve lesson planning classroom instruction and assessment processes.

Overall, the TPACK framework provides a comprehensive model for understanding how AI technologies can support modern teaching practices. By examining each component of the framework this study explores how ChatGPT contributes to the development of teachers technological pedagogical and content related competencies.

LITERATURE REVIEW

Artificial Intelligence in Education

The use of AI in the context of education has received increased attention from researchers in the last few years. It is a common consensus that AI technologies have the potential to contribute to the improvement of education, learning, and educational decisions. Luckin and Holmes (2016) argue that AI systems have the potential to assist educators in the process of providing education, learning, and decision-making. This is evident in the authors' work, which highlights the potential of AI technologies to revolutionize conventional learning approaches. Similarly, Holmes et al. (2019) argue that AI technologies have the potential to improve education by assisting educators in handling learning tasks, learning data, and developing personalized learning for students. The authors highlight that AI technologies have the potential to improve education by enabling educators to focus on pedagogical interactions, where tasks such as content generation and information retrieval can be supported by AI technologies.

Furthermore, Zawacki-Richter et al. (2019) conducted a systematic review of studies on the use of AI in higher education settings. The authors found that there is an increased tendency towards the use of AI technologies for supporting learning, assessment, and academic support services. The authors highlight that AI technologies are useful for instructional design and enhancing learning accessibility. Among the most discussed GenAI tools for supporting learning and teaching is ChatGPT. ChatGPT is a GenAI model developed by OpenAI. It is a large language model with the capacity to generate human-like responses and assist in creating written content. However, researchers have also begun to explore and discuss the educational potential of this AI model and its potential for supporting learning and teaching.

In a study on the opportunities and challenges associated with large language models, including ChatGPT, in educational contexts, Kasneci et al. (2023) noted that ChatGPT and similar models may help teachers in creating learning content, understanding complex concepts, and developing learning activities. Moreover, it was noted in this study that the ability of large language models, including ChatGPT, to generate explanations and examples may be beneficial for teachers in developing learning activities. Cotton et al. (2024) in their study on the potential of ChatGPT in supporting learning and teaching in higher education, noted that GenAI models, including ChatGPT, may help teachers in developing learning activities and educational content. At the same time, it was noted in this study that it is necessary to develop guidelines for

teachers to ensure ethical uses of these models in higher education contexts, including academic integrity.

In another study on the potential of GenAI in supporting learning and teaching, Tlili et al. (2023) noted that GenAI models, including ChatGPT, may help teachers in developing learning content, providing immediate explanations, and developing interactive learning activities. According to this study, GenAI models, including ChatGPT, hold potential in supporting learning and teaching.

Despite these opportunities, critical scholars have raised significant concerns about the educational use of GenAI. Bender et al. (2021) caution that large language models can produce confident yet factually incorrect outputs commonly termed hallucination and may amplify biases embedded in their training data, with direct implications for educational equity and content accuracy. Miao and Holmes (2023) have issued guidance for the responsible use of GenAI in education, emphasizing data privacy, informed consent, and ethical AI governance as non-negotiable dimensions of responsible adoption. In this context, effective AI integration demands not only operational proficiency but also critical AI literacy the capacity to evaluate, interrogate, and contextualize AI-generated content within disciplinary and pedagogical frameworks (Celik, 2023; Lo, 2023; Ng et al., 2021). The present study therefore positions TK as a domain that must extend beyond operational familiarity with ChatGPT to encompass ethical awareness and critical digital competence.

The TPACK Framework and Technology Integration

This framework has widely been used in research for understanding the role of teachers in integrating technology with instructional practices in the classroom. This framework was initially proposed in the form of PCK by Shulman (1986). It highlighted the importance of teachers' knowledge in integrating content with pedagogy. Mishra and Koehler (2006) further extended this framework in the form of TPACK, which highlighted the importance of understanding the relationship between TK, PK, and CK in the context of education. According to the authors, teachers should be able to understand the importance of integrating technology with pedagogy and content in order to be effective in the classroom.

Mishra and Koehler (2006) argue that teachers should be able to understand the importance of integrating technology with pedagogy and content in order to be effective in the classroom. They emphasize that successful technology integration depends not on the technology itself, but on the dynamic interaction among TK, PK, and CK, which together support effective instructional practice.

This study therefore examines teachers' perceptions of ChatGPT support across each TPACK domain, with particular attention to whether teachers perceive gaps in the technological and ethical competencies required for responsible AI-assisted teaching.

The Role of ChatGPT in Enhancing Teachers' TPACK

Recent studies have begun to explore the potential of ChatGPT to support some aspects of teachers' knowledge within the TPACK framework. For example, ChatGPT has been reported to assist teachers in identifying appropriate digital resources, developing instructional materials, and designing learning activities that align with curriculum objectives and students' learning needs (Kasneci et al., 2023; Tlili et al., 2023). Holmes et al. (2019) also suggested that AI technologies can support teachers in organizing and presenting subject content more effectively, thereby facilitating technology-enhanced instruction. These findings indicate that GenAI has the potential to support teachers' TK, PK, and CK. However, existing studies have primarily focused on specific instructional applications or selected TPACK components, and empirical evidence examining teachers' perceived support from ChatGPT across all seven TPACK domains remains limited. Furthermore, the effective integration of ChatGPT depends on teachers' ability to critically evaluate AI-generated content, apply appropriate pedagogical judgment, and use AI tools responsibly within their teaching practice.

Overall, the literature highlights both the opportunities and challenges associated with integrating GenAI into education. While ChatGPT has demonstrated considerable potential to support teaching and learning, teachers increasingly require competencies that extend beyond traditional TK to include AI literacy, ethical awareness, and the critical evaluation of AI-generated content. In this context, Demir et al. (2026) proposed an extended GenAI-TPACK model comprising three inseparable facets and five new knowledge domains explicitly tailored to the affordances and constraints of GenAI tools. This emerging framework underscores the need for empirical studies that map how specific GenAI tools such as ChatGPT align with established TPACK constructs across diverse educational contexts.

Building on these findings, the present study examines teachers' perceptions of ChatGPT support for instructional practices across all seven TPACK domains among in-service teachers in UAE schools, thereby contributing to the growing body of knowledge on AI-supported teaching and teacher professional development.

RESEARCH METHODOLOGY

Research Design

This study employed a quantitative cross-sectional survey design to examine in-service teachers' perceptions of ChatGPT support for the integration of technology, pedagogy, and content within the TPACK framework. Because the design captures self-reported perceptions at a single point in time, it does not permit causal conclusions about ChatGPT's effects or changes in teachers' TPACK competence.

Participants and Sample

The study was conducted in the UAE, a context in which national education strategies have actively promoted digital transformation and AI integration in schools. Participants were 109 in-service teachers enrolled in a postgraduate diploma in teaching program at a higher education institution in the UAE during the second semester of the 2024-2025 academic year. Purposive sampling was employed, with the primary inclusion criterion being active and demonstrated experience using ChatGPT for professional teaching activities. This criterion ensured that responses reflected informed, practice-based perceptions rather than hypothetical attitudes, thereby enhancing the contextual validity of the data. All 109 enrolled and eligible teachers participated, yielding a full response rate within the target group. Although the sample size is modest, it is consistent with comparable survey-based TPACK studies (Schmid et al., 2021) and provides adequate statistical power for the descriptive and non-parametric analyses employed. Given that 93.6% of participants were from private schools in the UAE, generalization to public-school settings and other national education systems should be approached with caution.

Research Instrument

A structured questionnaire was adopted for this study to assess in-service teachers' perceptions of ChatGPT support for teaching practices associated with the seven TPACK domains. The questionnaire was informed by the theoretical foundations of the TPACK model proposed by Mishra and Koehler (2006) and by previous research on teachers' knowledge domains under the TPACK model. The instrument was designed to measure perceived support and perceived contribution in TPACK-related practices rather than teachers' actual TPACK competence. Accordingly, items asked respondents to reflect on their own use, perceptions, and experiences of ChatGPT in teaching contexts.

The questionnaire had two main components. The first collected demographic information, including gender, age, academic qualification, teaching experience, subject taught, grade level, and school type. The second

consisted of 56 items addressing teachers' perceptions of ChatGPT support across seven TPACK domains: TK (12 items), PK (10 items), CK (11 items), PCK (6 items), TPK (6 items), TCK (6 items), and TPACK (5 items). All items were measured using a five-point Likert scale ranging from 1 (not at all) to 5 (all the time).

Content validity was established through expert review by specialists in educational technology and research methodology, who evaluated item relevance, clarity, and representativeness for each TPACK subscale. Because several items ask respondents to evaluate what ChatGPT supports or can provide, the instrument primarily captures teachers' perceptions of ChatGPT support for TPACK-related practices rather than direct measures of teachers' TPACK knowledge or competence. This distinction is acknowledged as a construct-validity consideration and is reflected throughout the RQs, analysis, discussion, and conclusion. Internal consistency reliability was assessed separately for each subscale: TK ($\alpha = .937$, 12 items), PK ($\alpha = .934$, 10 items), CK ($\alpha = .964$, 11 items), PCK ($\alpha = .950$, 6 items), TPK ($\alpha = .944$, 6 items), TCK ($\alpha = .946$, 6 items), and TPACK ($\alpha = .935$, 5 items), with an overall instrument $\alpha = .987$. These values indicate strong internal consistency across the seven subscales.

Because the questionnaire was designed to examine teachers' perceptions of ChatGPT within the TPACK framework, the items primarily captured teachers' perceived support and contribution of ChatGPT to TPACK-related teaching practices rather than directly measuring teachers' underlying TPACK knowledge or competence. Some items may therefore reflect teachers' perceptions of ChatGPT's capabilities in addition to their perceptions of their own knowledge, skills, and practices. Accordingly, the findings should be interpreted as evidence of teachers' perceived contribution of ChatGPT across TPACK-related domains rather than as an objective assessment of teachers' TPACK competence. This distinction is particularly relevant given the cross-sectional self-report design of the study and is acknowledged as a limitation of the instrument's construct validity.

Data Collection Procedure

An online survey was distributed via email during the second semester of the 2024-2025 academic year. Participants received instructions on completing the survey and were informed that participation was voluntary, responses would be treated confidentially, and no personally identifying information was requested. Participants provided informed consent before completing the questionnaire.

Data Analysis

The data were analyzed using descriptive statistics, including means (Ms), standard deviations (SDs),

Table 1. Participants' demographic data

Variable	Category	n	P (%)
Gender	Female	85	78.0
	Male	24	22.0
	Total	109	100
Age	Above 35	45	41.3
	31-35	37	33.9
	26-30	20	18.3
	20-25	7	6.4
	Total	109	100
Highest academic qualification	Bachelors	77	70.6
	Master	18	16.5
	Postgraduate diploma	13	11.9
	PhD	1	0.9
	Total	109	100
Teaching experience	10+ years	38	34.9
	1-2 years	31	28.4
	3-5 years	22	20.2
	6-9 years	18	16.5
	Total	109	100
Grade level	Secondary	41	37.6
	Primary	34	31.2
	Intermediate	23	21.1
	Multiple levels	6	5.5
	Kindergarten	5	4.6
	Total	109	100
Type of school	Private	102	93.6
	Public	7	6.4
	Total	109	100

Note. n: Frequency & P: Percentage

medians (Mdns), and frequency distributions, to summarize teachers' perceptions of ChatGPT support across the seven TPACK domains. Domain scores were calculated as the arithmetic mean of the items belonging to each respective TPACK subscale. The overall TPACK score was calculated for each participant as the arithmetic mean of the seven domain scores (TK, PK, CK, PCK, TPK, TCK, and TPACK), and the reported overall descriptive statistics were then calculated from these participant-level composite scores. Inferential analyses were used to examine differences in teachers' perceptions across demographic groups. Normality was assessed using the Shapiro-Wilk test, and non-parametric tests were selected where assumptions were not met. A Wilcoxon signed-rank test was used to compare paired CK and TK scores. All analyses were conducted using SPSS version 29.

Ethical Considerations

This research was carried out following the ethical standards set for research. This research received approval by the Research Ethics Committee at Ajman University, with approval number (H-F-H-13-Nov-ii) before carrying out the data collection process. The respondents were briefed about the objective of this research as well as their rights, which include voluntary

participation, withdrawal at any point in time without any repercussions, and confidentiality of responses.

FINDINGS AND RESULTS

This section highlights the findings based on the analysis of the responses gathered from 109 in-service teachers. Descriptive statistics were used to compute Ms and SDs for each item, with a five-point Likert scale, where 1 indicates "not at all", 2 "rarely", 3 "occasionally", 4 "frequently", and 5 "all the time". The interpretative range of means was: 1.00-1.80 = not at all; 1.81-2.60 = rarely; 2.61-3.40 = occasionally; 3.41-4.20 = frequently; 4.21-5.00 = all the time.

Participants' Demographic Data

The study surveyed 109 participants, with females forming the majority ($n = 85$, 78.0%), while males accounted for 22.0% ($n = 24$). In terms of age distribution, it was found that most participants were above 35 years old (41.3%), followed by those aged 31-35 (33.9%), 26-30 (18.3%), and 20-25 (6.4%), showing that they were mid-career and experienced educators. Regarding academic qualifications, it was found that most participants possessed a bachelor's degree (70.6%), while a smaller number possessed a master's degree (16.5%), postgraduate diploma (11.9%), and PhD (0.9%). In relation to years of experience, it was found that most participants possessed more than 10 years of experience (34.9%), while a smaller number possessed 1-2 years (28.4%), 3-5 years (20.2%), and 6-9 years (16.5%), showing a diversified range of experience among participants.

In terms of level of teaching, it was found that most participants taught at the secondary level (37.6%), while a smaller number taught at the primary (31.2%) and intermediate (21.1%) levels. In terms of school types, it was found that most participants were from private schools (93.6%), while a smaller number were from public schools (6.4%), as shown in [Table 1](#).

RQ1: Technological Knowledge

RQ1 explored the level of in-service teachers' TK about using ChatGPT. As shown in [Table 2](#), the overall average for the construct of TK was $M = 3.25$ ($SD = 0.94$), which was interpreted as "occasionally." This suggests that although teachers have a general working familiarity with using ChatGPT, their level of TK is average and does not reflect proficiency or consistent usage.

In terms of specific items, familiarity with ChatGPT technology was reported at the highest level, $M = 3.90$ ($SD = 1.02$), with 69.7% of teachers reporting usage "frequently" or "all the time." This suggests a relatively high level of familiarity among teachers.

Table 2. Descriptive statistics for TK

No	Item	Percentage (%)					M	SD
		NA (1)	R (2)	O (3)	F (4)	AT (5)		
1	Familiarity with ChatGPT technology	3.9	1.018	21.1	37.6	32.1	3.90	1.02
2	Previous work/utilization of ChatGPT for specific applications	3.63	1.136	25.7	31.2	26.6	3.63	1.14
3	Awareness of underlying technologies (NLP, machine learning)	3.35	1.189	27.5	33.9	16.5	3.35	1.19
4	Formal training/educational programs related to ChatGPT	2.65	1.462	22.0	18.3	13.8	2.65	1.46
5	Understanding of ethical considerations and potential biases	3.51	1.111	28.4	33.9	20.2	3.51	1.11
6	Familiarity with ChatGPT architecture (GPT-3.5)	3.08	1.32	22.9	29.4	14.7	3.08	1.32
7	Confidence in ensuring data privacy and security	3.01	1.243	26.6	26.6	11.9	3.01	1.24
8	Familiarity with recent advancements in language models	2.89	1.197	28.4	27.5	7.3	2.89	1.20
9	Comfort with troubleshooting technical issues	3.21	1.284	22.9	25.7	19.3	3.21	1.28
10	Experience with fine-tuning ChatGPT models	2.77	1.31	26.6	18.3	11.9	2.77	1.31
11	Use of ChatGPT for NLU and generation tasks	3.37	1.237	22.9	38.5	16.5	3.37	1.24
12	Self-rated proficiency in using ChatGPT	3.52	1.094	28.4	35.8	19.3	3.52	1.09
Overall mean							3.25	0.94

Note. NA: Not at all; R: Rarely; O: Occasionally; F: Frequently; AT: All the time

Table 3. Descriptive statistics for PK

No	Item	Percentage (%)					M	SD
		NA (1)	R (2)	O (3)	F (4)	AT (5)		
1	Solid understanding of pedagogical principles	6.4	10.1	29.4	39.4	14.7	3.46	1.07
2	Frequency of integrating ChatGPT into teaching methodologies	4.6	15.6	34.9	36.7	8.3	3.28	0.98
3	Familiarity with educational applications of ChatGPT	11.0	16.5	29.4	28.4	14.7	3.19	1.21
4	Confidence in adapting ChatGPT for diverse educational contexts	3.7	11.0	27.5	37.6	20.2	3.60	1.05
5	Inclusion of ChatGPT in lesson planning	7.3	11.0	29.4	33.0	19.3	3.46	1.14
6	ChatGPT's impact on student engagement and participation	5.5	12.8	32.1	33.9	15.6	3.41	1.07
7	Plans to further integrate ChatGPT in future teaching	3.7	3.7	25.7	42.2	24.8	3.81	0.98
8	Challenges encountered when incorporating ChatGPT	7.3	20.2	33.0	25.7	13.8	3.18	1.13
9	Participation in professional development on ChatGPT	20.2	19.3	25.7	20.2	14.7	2.90	1.34
10	ChatGPT's alignment with pedagogical goals and objectives	8.3	5.5	28.4	45.9	11.9	3.48	1.05
Overall mean							3.36	0.88

Note. NA: Not at all; R: Rarely; O: Occasionally; F: Frequently; AT: All the time

Similarly, teachers reported a relatively high level of self-rated proficiency, $M = 3.52$ ($SD = 1.09$), and experience using ChatGPT for natural language processing, $M = 3.37$ ($SD = 1.24$), although both of these averages were somewhat lower. The lowest levels of familiarity were reported for formal training about using ChatGPT, $M = 2.65$ ($SD = 1.46$), with 45.9% of teachers reporting "not at all" or "rarely." Similarly, experience using ChatGPT for fine-tuning, $M = 2.77$ ($SD = 1.31$), was also reported at a relatively low level. Familiarity with recent advancements in language models, $M = 2.89$ ($SD = 1.20$), and teachers' confidence about data privacy and security, $M = 3.01$ ($SD = 1.24$), also reported below "frequently."

RQ2: Pedagogical Knowledge

RQ2 aimed to examine teachers' perceptions of ChatGPT support for pedagogical practices. As indicated in **Table 3**, the PK construct had an overall mean of $M = 3.36$ ($SD = 0.88$), corresponding to "occasionally." This indicates a moderate level of perceived support for teachers' pedagogical practices. The highest rating concerned teachers' intention to further integrate ChatGPT into future teaching ($M = 3.81$,

$SD = 0.98$), with 67.0% responding "frequently" or "all the time." Teachers also reported relatively positive perceptions of adapting ChatGPT to different educational settings ($M = 3.60$, $SD = 1.05$) and aligning ChatGPT with pedagogical goals ($M = 3.48$, $SD = 1.05$). In contrast, participation in professional development was rated lowest ($M = 2.90$, $SD = 1.34$), indicating limited formal training opportunities. These findings suggest that positive perceptions and intentions to use ChatGPT are not necessarily accompanied by comparable levels of professional development.

RQ3: Content Knowledge

RQ3 explored the degree to which ChatGPT helps teachers create content for their lesson plan, ensuring it is accurate, reliable, and relevant, as well as appropriate for inclusion within a curriculum. As can be observed from **Table 4**, it was evident that the CK construct received the highest overall average for all constructs ($M = 3.53$, $SD = 0.89$), falling within the "frequently" range. This indicates that in-service teachers perceive ChatGPT as a tool of frequent usefulness in enhancing the quality, relevance, and appropriateness of their lesson plan content. The highest rating was received for the

Table 4. Descriptive statistics for CK

No	Item	Percentage (%)					M	SD
		NA (1)	R (2)	O (3)	F (4)	AT (5)		
1	ChatGPT's assistance in aligning lesson plan with curriculum	2.8	12.8	26.6	36.7	21.1	3.61	1.05
2	ChatGPT's contribution to meeting students' learning needs	5.5	9.2	33.9	33.9	17.4	3.49	1.06
3	ChatGPT's ability to cater to diverse learning styles	6.4	11.0	36.7	29.4	16.5	3.39	1.09
4	ChatGPT's consideration of students' language abilities	7.3	11.9	35.8	28.4	16.5	3.35	1.12
5	Accuracy of content generated by ChatGPT	4.6	10.1	34.9	39.4	11.0	3.42	0.98
6	Currency and up-to-date information provided by ChatGPT	3.7	8.3	33.0	44.0	11.0	3.50	0.93
7	Relevance of the lesson plan content created with ChatGPT	4.6	7.3	36.7	29.4	22.0	3.57	1.06
8	Reliability of information generated by ChatGPT	2.8	9.2	33.0	40.4	14.7	3.55	0.95
9	Meaningfulness of ChatGPT's contribution to lesson planning	3.7	7.3	30.3	36.7	22.0	3.66	1.02
10	ChatGPT's enhancement of lesson plan content clarity	4.6	3.7	36.7	38.5	16.5	3.59	0.96
11	ChatGPT's effectiveness in overall lesson plan development	5.5	6.4	28.4	38.5	21.1	3.63	1.06
Overall mean							3.51	0.89

Note. NA: Not at all; R: Rarely; O: Occasionally; F: Frequently; AT: All the time

Table 5. Descriptive statistics for PCK

No	Item	Percentage (%)					M	SD
		NA (1)	R (2)	O (3)	F (4)	AT (5)		
1	ChatGPT facilitated pedagogies for meaningful learning	9.2	6.4	29.4	44.0	11.0	3.41	1.07
2	ChatGPT facilitated pedagogies for engaging learning	5.5	10.1	30.3	35.8	18.3	3.51	1.08
3	ChatGPT facilitated pedagogies for creative learning	6.4	9.2	32.1	35.8	16.5	3.47	1.08
4	ChatGPT facilitated pedagogies for reflective learning	4.6	14.7	30.3	32.1	18.3	3.45	1.09
5	ChatGPT facilitated pedagogies for fun learning	8.3	11.9	29.4	34.9	15.6	3.38	1.14
6	ChatGPT facilitated pedagogies for interesting learning	5.5	6.4	40.4	32.1	15.6	3.46	1.01
Overall mean							3.45	0.96

Note. NA: Not at all; R: Rarely; O: Occasionally; F: Frequently; AT: All the time

meaningfulness of the contribution of ChatGPT in the development of their lesson plan ($M = 3.66$, $SD = 1.02$), for which 58.7% of teachers responded using "frequently" or "all the time." The next highest rating was received for overall effectiveness in facilitating the development of their lesson plan ($M = 3.63$, $SD = 1.06$), for assistance in making their lesson plan more relevant to the curriculum ($M = 3.61$, $SD = 1.05$), and for enhancing clarity of content ($M = 3.59$, $SD = 0.96$). The rating for content accuracy ($M = 3.42$, $SD = 0.97$) and currency of information ($M = 3.50$, $SD = 0.93$) also showed a positive rating, suggesting that teachers perceive content generated using ChatGPT as reliable and up-to-date. The rating for addressing diverse learning styles ($M = 3.39$, $SD = 1.09$) and for accommodating students' language abilities ($M = 3.35$, $SD = 1.12$) showed a relatively lower rating, suggesting that although it performs well overall, it is relatively weaker at addressing differentiated learning needs.

RQ4: Pedagogical Content Knowledge

RQ4 examined how ChatGPT enhances teachers' PCK in designing meaningful, engaging, and reflective learning experiences. **Table 5** presents the descriptive statistics for the PCK construct, which yielded an overall mean of $M = 3.45$ ($SD = 0.96$), classified as "frequently". This suggests that ChatGPT is perceived as a frequent contributor to teachers' capacity to design instructional experiences that integrate both content and pedagogy.

Among the six PCK items, ChatGPT's facilitation of engaging learning ($M = 3.51$, $SD = 1.08$) and creative learning ($M = 3.47$, $SD = 1.08$) received the highest ratings, followed by reflective learning ($M = 3.45$, $SD = 1.09$) and interesting learning ($M = 3.46$, $SD = 1.01$). ChatGPT's support for meaningful learning experiences scored $M = 3.41$ ($SD = 1.07$), with 55.0% of respondents rating it "frequently" or "all the time". The lowest-rated item was facilitation of fun learning ($M = 3.38$, $SD = 1.14$), where 20.2% responded "not at all" or "rarely", suggesting that ChatGPT's contributions to affective and experiential dimensions of learning remain less consistent. Overall, the PCK findings indicate that ChatGPT meaningfully supports teachers in designing pedagogically rich content-integrated lessons, with particular strength in fostering engagement, creativity, and interest, and a comparatively weaker role in fostering reflective and fun-oriented learning modalities.

RQ5: Technological Pedagogical Knowledge

Table 6 presents the descriptive statistics for teachers' perceptions of ChatGPT's support for TPK. The overall mean for TPK was 3.43 ($SD = 0.95$), indicating that teachers frequently perceived ChatGPT as supporting their technological pedagogical practices.

At the item level, the highest-rated statement was "ChatGPT proposes interactive technologies to enrich teaching materials" ($M = 3.50$, $SD = 1.09$), followed by "ChatGPT suggests technologies that enrich teaching

Table 6. Descriptive statistics for TPK

No	Item	Percentage (%)					M	SD
		NA (1)	R (2)	O (3)	F (4)	AT (5)		
1	ChatGPT suggests technologies for interactive student activities	6.4	12.8	33.0	35.8	11.9	3.34	1.06
2	ChatGPT suggests technologies that explain subject matter content	6.4	10.1	35.8	32.1	15.6	3.40	1.07
3	ChatGPT suggests technologies that enhance teaching effectiveness	4.6	8.3	37.6	34.9	14.7	3.47	1.00
4	ChatGPT suggests technologies that motivate students	8.3	11.9	30.3	33.0	16.5	3.38	1.15
5	ChatGPT proposes interactive technologies to enrich teaching materials	3.7	15.6	27.5	33.9	19.3	3.50	1.09
6	ChatGPT suggests technologies that enrich teaching content	5.5	11.9	29.4	35.8	17.4	3.48	1.09
Overall mean							3.43	0.95

Note. NA: Not at all; R: Rarely; O: Occasionally; F: Frequently; AT: All the time

Table 7. Descriptive statistics for TCK

No	Item	Percentage (%)					M	SD
		NA (1)	R (2)	O (3)	F (4)	AT (5)		
1	ChatGPT suggests technologies to enhance content understanding	5.5	11.9	33.0	32.1	17.4	3.44	1.08
2	ChatGPT suggests technologies to explain concepts in course content	6.4	15.6	31.2	27.5	19.3	3.38	1.15
3	ChatGPT suggests technologies for unit-specific teaching activities	5.5	12.8	32.1	33.0	16.5	3.42	1.08
4	ChatGPT suggests appropriate technology for specific course units	5.5	15.6	29.4	29.4	20.2	3.43	1.14
5	ChatGPT proposes technologies to organize information effectively	5.5	13.8	29.4	34.9	16.5	3.43	1.09
6	ChatGPT integrates content, technologies, and teaching approaches	4.6	8.3	36.7	34.9	15.6	3.49	1.01
Overall mean							3.43	0.99

Note. NA: Not at all; R: Rarely; O: Occasionally; F: Frequently; AT: All the time

content" ($M = 3.48$, $SD = 1.09$) and "ChatGPT suggests technologies that enhance teaching effectiveness" ($M = 3.47$, $SD = 1.00$). These items all fell within the "frequently" category, indicating that teachers frequently perceived ChatGPT as supporting the selection and use of technologies to enrich instructional materials and content and to enhance teaching effectiveness. The lowest-rated item was "ChatGPT suggests technologies for interactive student activities" ($M = 3.34$, $SD = 1.06$), which was also classified as "occasionally".

Overall, the findings indicate that teachers frequently perceived ChatGPT as supporting TPK-related practices, although perceptions varied across individual items. The highest perceptions concerned the use of ChatGPT to identify or propose technologies for enriching teaching materials, enriching teaching content, and enhancing teaching effectiveness.

In contrast, its perceived support for technologies related to interactive student activities, explaining subject matter, and motivating students was rated as occurring occasionally.

RQ6: Technological Content Knowledge

Table 7 presents the descriptive statistics for teachers' perceptions of ChatGPT's support for TCK. The overall mean was 3.43 ($SD = 0.99$), which falls within

the "frequently" category according to the study's interpretative criteria. This indicates that teachers frequently perceived ChatGPT as supporting the integration of technology with subject-matter content. All six TCK items were classified as "frequently", with mean scores ranging from 3.38 to 3.49.

The highest-rated statement was "ChatGPT integrates content, technologies, and teaching approaches" ($M = 3.49$, $SD = 1.01$). This was followed by "ChatGPT suggests technologies to enhance content understanding" ($M = 3.44$, $SD = 1.08$). Both items indicate that teachers frequently perceived ChatGPT as supporting the connection between technological options, subject-matter content, and teaching approaches. The lowest-rated item was "ChatGPT suggests technologies to explain concepts in course content" ($M = 3.38$, $SD = 1.15$). Although this was the lowest-rated TCK item, it should be noted that 3.38 falls within the Occasionally category, rather than "frequently," according to the study's interpretative criteria.

Overall, the findings indicate that teachers frequently perceived ChatGPT as supporting TCK-related practices, particularly in integrating content, technologies, and teaching approaches and in identifying technologies that may enhance content understanding. However, the lower rating for using

Table 8. Descriptive statistics for TPACK integration

No	Item	Percentage (%)					M	SD
		NA (1)	R (2)	O (3)	F (4)	AT (5)		
1	ChatGPT integrates contexts to promote learning and inquiry	4.6	12.8	30.3	33.9	18.3	3.49	1.08
2	ChatGPT integrates technologies to assess understanding of abstract concepts	5.5	14.7	31.2	31.2	17.4	3.40	1.11
3	ChatGPT integrates different teaching approaches across course units	6.4	9.2	39.4	32.1	12.8	3.36	1.03
4	ChatGPT integrates technologies to enhance teaching approaches	5.5	11.0	39.4	32.1	11.9	3.34	1.01
5	ChatGPT consistently integrates content, technologies, and teaching approaches	3.7	5.5	35.8	33.0	22.0	3.64	1.01
Overall mean							3.43	0.94

Note. NA: Not at all; R: Rarely; O: Occasionally; F: Frequently; AT: All the time

technologies to explain course concepts suggests that teachers perceived this particular form of support as occurring “occasionally”.

Taken together, the findings for **RQ5** and **RQ6** show that the overall perceptions of ChatGPT support for TPK ($M = 3.43$, $SD = 0.95$) and TCK ($M = 3.43$, $SD = 0.99$) were both within the “frequently” category. The two domains therefore received very similar overall ratings.

RQ7: TPACK Integration

RQ7 sought to determine the degree to which teachers perceive ChatGPT as supporting the comprehensive integration of TK, PK, and CK (TPACK) in teachers’ instructional practices. As shown in **Table 8**, the TPACK construct produced an overall mean of $M = 3.43$ ($SD = 0.94$), classified as “frequently”, indicating that in-service teachers perceive ChatGPT as a frequent facilitator of comprehensive TPACK integration.

The highest-rated TPACK item was ChatGPT’s consistent integration of content, technologies, and teaching approaches to teach subject units ($M = 3.64$, $SD = 1.00$), with 55.0% of respondents rating it “frequently” or “all the time”. This was followed by ChatGPT’s integration of contexts to promote learning and inquiry ($M = 3.49$, $SD = 1.08$) and its use of technologies to assess students’ understanding of abstract concepts ($M = 3.40$, $SD = 1.11$).

Items related to integrating different teaching approaches across course units ($M = 3.36$, $SD = 1.03$) and enhancing teaching approaches through technology integration ($M = 3.34$, $SD = 1.01$) received comparatively lower scores, suggesting that while ChatGPT supports the core tenet of TPACK the seamless blending of content, technology, and pedagogy its capacity to flexibly diversify teaching approaches across units remains a relative limitation. Overall, the findings affirm that ChatGPT is a meaningful enabler of TPACK integration, particularly in content-technology alignment, though broader and more adaptive pedagogical integration represents an area for continued development.

Table 9. Shapiro-Wilk normality test full sample ($N = 109$)

Construct	N	W	p	Normal?
TK	109	0.982	.162	Yes
PK	109	0.974	.030	No*
CK	109	0.966	.007	No*
PCK	109	0.958	.002	No*
TPK	109	0.960	.003	No*
TCK	109	0.964	.005	No*
TPACK	109	0.961	.003	No*
Overall TPACK	109	0.975	.036	No*

Note. W: Shapiro-Wilk statistic; * $p < .05$ indicates violation of normality; TK was the only construct satisfying normality at the full-sample level

RQ8: Demographic Differences in Teachers’ Perceptions of ChatGPT Support for TPACK-Related Practices

RQ8 examined whether there are significant differences in teachers’ perceptions of ChatGPT’s perceived contribution to TPACK components based on three demographic variables: gender, teaching experience, and academic qualification. Before conducting inferential statistical analyses, the assumption of normality was assessed for all six TPACK construct scores and the overall TPACK score using the Shapiro-Wilk test, which is recommended for sample sizes below 300 (Field, 2018). Homogeneity of variance was subsequently evaluated using Levene’s test. Results are presented on tables.

Shapiro-Wilk test in **Table 9** results revealed that the normality assumption was violated for the majority of TPACK construct scores at the full-sample level (PK, CK, PCK, TPK, TCK, TPACK, and overall TPACK, all $p < .05$). At the subgroup level, significant departures from normality were observed among female teachers for CK, PCK, TPK, TCK and TPACK, and among teachers with 3-5 years of teaching experience for CK. For academic qualification, significant departures from normality were observed for TPACK among teachers holding a bachelor’s degree.

Table 10. Shapiro-Wilk normality test by gender

Construct	Male (n = 24)			Female (n = 85)		
	W	p	Normal?	W	p	Normal?
TK	0.955	.345	Yes	0.984	.367	Yes
PK	0.951	.291	Yes	0.971	.051	Yes
CK	0.950	.272	Yes	0.967	.027	No*
PCK	0.963	.506	Yes	0.958	.007	No*
TPK	0.955	.338	Yes	0.956	.006	No*
TCK	0.951	.289	Yes	0.958	.008	No*
TPACK	0.970	.659	Yes	0.956	.005	No*
Overall TPACK	0.941	.173	Yes	0.973	.072	Yes

Note. *p < .05 indicates violation of normality; Female group showed significant departures from normality for CK, PCK, TPK, TCK, and TPACK

Table 11. Shapiro-Wilk normality test by teaching experience

Construct	1-2 years (n = 31)		3-5 years (n = 22)		6-9 years (n = 18)		10+ years (n = 38)	
	W	p	W	p	W	p	W	p
TK	0.976	.700	0.988	.993	0.969	.780	0.973	0.472
PK	0.966	.414	0.971	.729	0.927	.171	0.962	0.217
CK	0.938	.074	0.904	.035*	0.934	.224	0.968	0.338
PCK	0.962	.328	0.942	.221	0.946	.370	0.946	0.067
TPK	0.936	.065	0.914	.056	0.909	.083	0.959	.171
TCK	0.944	.108	0.972	.758	0.915	.107	0.957	0.151
TPACK	0.937	.067	0.951	.332	0.912	.094	0.950	0.091
Overall TPACK	0.959	.282	0.958	.448	0.939	.280	0.978	0.659

Note. *p < .05 indicates violation of normality; Only CK in the 3-5 years group showed significant departures from normality

Table 12. Shapiro-Wilk normality test by academic qualification

Construct	Bachelors (n = 77)		Postgraduate diploma (n = 13)		Master (n = 18)	
	W	p	W	p	W	p
TK	0.985	.504	0.953	.651	0.962	.632
PK	0.977	.175	0.951	.616	0.963	.665
CK	0.972	.086	0.945	.523	0.957	.552
PCK	0.968	.050	0.930	.339	0.917	.116
TPK	0.968	.047	0.931	.349	0.927	.169
TCK	0.963	.026*	0.948	.570	0.945	.359
TPACK	0.962	.023*	0.927	.315	0.970	.789
Overall TPACK	0.981	.288	0.949	.587	0.967	.735

Note. *p < .05 indicates violation of normality; TCK, and TPACK in the bachelor's group showed significant departures from normality; PhD group (n = 1) excluded

Table 10 shows the Shapiro-Wilk normality test by gender. **Table 11** depicts the Shapiro-Wilk normality test by teaching experience. **Table 12** demonstrates the Shapiro-Wilk normality test by academic qualification.

Table 13 shows Levene's test for homogeneity of variance across all demographic groups.

Levene's test results were mixed across demographic groups. For the gender and teaching experience groups, all $p > .05$, confirming homogeneity of variance across constructs. However, for the academic qualification group, significant violations of homogeneity of variance were observed for PK ($F = 4.776$, $p = .01$), PCK ($F = 5.194$, $p = .007$), TPACK ($F = 5.782$, $p = .004$), and overall TPACK ($F = 3.824$, $p = .025$). Together, the pervasive violations of normality across multiple constructs and the additional heterogeneity of variance in the qualification group render parametric tests inappropriate. Accordingly, the Mann-Whitney U test

was employed for gender comparisons and the Kruskal-Wallis H test for experience and qualification comparisons (Field, 2018; Pallant, 2016). Effect sizes are reported as $r = Z / \sqrt{N}$ for the Mann-Whitney U test (small: $r \geq .10$; medium: $r \geq .30$; large: $r \geq .50$) and $\eta^2 = (H - k + 1) / (N - k)$ for the Kruskal-Wallis test (small: $\eta^2 \geq .01$; medium: $\eta^2 \geq .06$; large: $\eta^2 \geq .14$).

Gender differences (Mann-Whitney U test)

As shown in **Table 14**, the Mann-Whitney U test revealed no statistically significant differences between male ($n = 24$) and female ($n = 85$) teachers across any of the six TPACK constructs or the overall TPACK score (all $p > .05$). For the overall TPACK score, male teachers recorded a median of 3.47 while female teachers recorded a median of 3.45, with $U = 911.0$, $Z = -0.797$, $p = 0.425$, $r = 0.076$ (negligible effect).

Table 13. Levene's test for homogeneity of variance across all demographic groups

Score	Grouping variable	Groups	Group sizes	Levene W	p	Decision at $\alpha = .05$
TK	Gender	2	85, 24	0.007	0.932	Homogeneity not rejected
PK				1.178	0.280	Homogeneity not rejected
CK				1.448	0.231	Homogeneity not rejected
PCK				1.750	0.189	Homogeneity not rejected
TPK				1.450	0.231	Homogeneity not rejected
TCK				0.279	0.599	Homogeneity not rejected
TPACK				0.002	0.964	Homogeneity not rejected
Overall TPACK				0.117	0.733	Homogeneity not rejected
TK	Teaching experience	4	38, 31, 22, 18	1.229	0.303	Homogeneity not rejected
PK				2.254	0.086	Homogeneity not rejected
CK				1.418	0.242	Homogeneity not rejected
PCK				1.198	0.314	Homogeneity not rejected
TPK				0.976	0.407	Homogeneity not rejected
TCK				2.315	0.080	Homogeneity not rejected
TPACK				2.637	0.054	Homogeneity not rejected
Overall TPACK				0.948	0.421	Homogeneity not rejected
TK	Academic qualification	4	77, 18, 1, 13	1.290	0.279	Homogeneity not rejected
PK				4.766	0.010	Unequal variances
CK				1.956	0.147	Homogeneity not rejected
PCK				5.194	0.007	Unequal variances
TPK				0.846	0.432	Homogeneity not rejected
TCK				2.727	0.070	Homogeneity not rejected
TPACK				5.782	0.004	Unequal variances
Overall TPACK				3.824	0.025	Unequal variances

Note. For gender and experience groups, all $p > .05$ confirms homogeneity of variance; For qualification group, significant violations were observed for PK ($p = .01$), PCK ($p = .007$), TPACK ($p = .004$), and overall TPACK ($p = .025$), providing extra justification for non-parametric testing

Table 14. Mann-Whitney U test results for gender differences in TPACK perceptions

Construct	Mdn		U	Z	p	r	Effect size	Significance
	Male (n = 24)	Female (n = 85)						
TK	3.54	3.23	902.5	-0.860	0.390	0.082	Negligible	NS
PK	3.50	3.36	870.5	-1.094	0.274	0.105	Small	NS
CK	3.79	3.58	862.5	-1.153	0.249	0.110	Small	NS
PCK	3.43	3.43	886.0	-0.983	0.325	0.094	Negligible	NS
TPK	3.57	3.43	914.0	-0.778	0.437	0.075	Negligible	NS
TCK	3.57	3.43	962.0	-0.426	0.670	0.041	Negligible	NS
TPACK	3.58	3.33	856.5	-1.200	0.230	0.115	Small	NS
Overall TPACK	3.47	3.45	911.0	-0.797	0.425	0.076	Negligible	NS

Note. N = 109 (male n = 24, female n = 85); U: Mann-Whitney U statistic; Z: Standardized test statistic; r: Effect size ($|Z|/\sqrt{N}$); *** $p < .001$; ** $p < .01$; * $p < .05$; NS: Not significant

The largest observed difference was in TK, where male teachers (Mdn = 3.54) scored marginally higher than female teachers (Mdn = 3.23); however, this difference did not reach statistical significance ($U = 902.5$, $Z = -0.86$, $p = 0.39$, $r = 0.082$). These findings suggest that gender does not meaningfully differentiate teachers perceive ChatGPT as supporting TPACK-related practices. This aligns with emerging evidence that AI tool adoption in educational settings tends to be gender-neutral when access and institutional support are equitable (Kasneci et al., 2023).

Teaching experience differences (Kruskal-Wallis H test)

The Kruskal-Wallis H test examined whether perceptions of ChatGPT's perceived contribution to TPACK differed across four teaching experience groups:

1-2 years (n = 31), 3-5 years (n = 22), 6-9 years (n = 18), and 10+ years (n = 38).

As presented in **Table 15**, no statistically significant differences were found across any construct or the overall TPACK score (all $p > .05$). For the overall TPACK score, $H(3) = 4.351$, $p = 0.226$, $\eta^2 = 0.013$ (negligible effect). Descriptively, teachers in the 6 - 9 years group recorded the highest median overall score (Mdn = 3.97), suggesting a possible inverted-U pattern of confidence mid-career teachers may feel most empowered by AI tools while the 1 - 2 years group reported the lowest median (Mdn = 3.28). However, these descriptive trends did not reach statistical significance, indicating that teaching experience does not significantly differentiate perceptions of ChatGPT's TPACK-related contribution. These results are consistent with studies suggesting that

Table 15. Kruskal-Wallis H test results for teaching experience differences in TPACK perceptions

Construct	Mdn				H	df	p	η^2	Effect size	Significance
	1-2 years (n = 31)	3-5 years (n = 22)	6-9 years (n = 18)	10+ years (n = 38)						
TK	3.00	3.50	3.54	3.23	4.106	3	0.250	0.011	Small	NS
PK	3.09	3.64	3.73	3.36	6.410	3	0.093	0.032	Small	NS
CK	3.25	3.92	3.92	3.63	6.290	3	0.098	0.031	Small	NS
PCK	3.14	3.36	4.00	3.64	3.361	3	0.339	0.003	Negligible	NS
TPK	3.57	3.14	4.00	3.14	4.935	3	0.177	0.018	Small	NS
TCK	3.29	3.36	4.00	3.07	5.389	3	0.145	0.023	Small	NS
TPACK	3.33	3.33	4.00	3.08	5.218	3	0.157	0.021	Small	NS
Overall TPACK	3.28	3.45	3.97	3.30	4.351	3	0.226	0.013	Small	NS

Note. N = 109; H: Kruskal-Wallis H statistic; η^2 : Eta-squared; NS: Not significant

Table 16. Kruskal-Wallis H test results for academic qualification differences in TPACK perceptions

Construct	Mdn			H	df	p	η^2	Effect size	Significance
	Bachelors (n = 77)	Postgraduate diploma (n = 13)	Master (n = 18)						
TK	3.23	3.54	3.58	5.122	2	.163	0.020	Small	NS
PK	3.36	3.64	3.45	2.374	2	.499	-0.006	Negligible	NS
CK	3.42	3.67	4.00	5.517	2	.138	0.024	Small	NS
PCK	3.43	3.00	4.00	5.527	2	.137	0.024	Small	NS
TPK	3.57	3.43	4.00	1.698	2	.637	-0.012	Negligible	NS
TCK	3.43	3.00	3.71	3.466	2	.325	0.004	Negligible	NS
TPACK	3.33	3.00	3.92	4.073	2	.254	0.010	Small	NS
Overall TPACK	3.33	3.02	3.67	3.799	2	.284	0.008	Negligible	NS

Note. N = 108 (PhD n = 1 excluded); H: Kruskal-Wallis H statistic; η^2 : Eta-squared; NS: Not significant

teachers' openness to AI tools is more strongly shaped by institutional support and personal motivation than by years of experience alone (Crompton & Burke, 2023; Mishra & Koehler, 2006).

Academic qualification differences (Kruskal-Wallis H test)

Differences in perceptions across academic qualification groups were similarly examined using the Kruskal-Wallis H test. The analysis included three groups with sufficient sample sizes: Bachelor's degree holders (n = 77), postgraduate diploma holders (n = 13), and master's degree holders (n = 18). The PhD group (n = 1) was excluded from analysis due to insufficient sample size.

As shown in **Table 16**, no statistically significant differences were found across any construct or the overall TPACK score (all $p > .05$). For the overall TPACK score, $H(2) = 3.799$, $p = .284$, $\eta^2 = .008$ (negligible effect). Descriptively, master holders reported the highest median overall score (Mdn = 3.67), which may reflect greater research exposure and critical engagement with AI tools; however, this did not translate into a statistically significant difference. The absence of qualification-based differences aligns with findings that perceived usefulness of AI educational tools is more closely linked to task-specific training than to general academic attainment (Kasneci et al., 2023; Zawacki-Richter et al., 2019).

Table 17. Overall mean and ranking of TPACK dimensions

Dimension	M	Average SD	Rank
CK	3.51	0.89	1
PCK	3.45	0.96	2
TPACK	3.43	0.94	3
TPK	3.43	0.95	4
TCK	3.43	0.99	5
PK	3.36	0.88	6
TK	3.25	0.94	7

Main RQ: Teachers' Perceptions of ChatGPT Support for TPACK Integration

The main RQ examined the extent to which teachers perceive ChatGPT as supporting their integration of content, pedagogy, and technology within the TPACK framework. Across the seven constructs TK, PK, CK, PCK, TPK, TCK, and TPACK, **Table 17** revealed that the mean scores ranged from 3.25 to 3.51. The overall TPACK score ($M = 3.41$, $SD = 0.86$) was calculated from the participant-level mean of the seven domain scores and fell within the "frequently" interpretation band. CK received the highest perceived support ($M = 3.51$), particularly for lesson planning, curriculum alignment, and instructional content preparation, whereas TK received the lowest ($M = 3.25$). Teachers' perceived support scores were higher for CK ($M = 3.51$, $SD = 0.89$, $Mdn = 3.58$) than for TK ($M = 3.25$, $SD = 0.94$, $Mdn = 3.31$). The Wilcoxon signed-rank test confirmed that the paired CK scores were significantly higher than the TK scores ($Z = -3.716$, $p < .001$, $r = .356$), indicating a medium

effect size. Overall, the pattern reflects teachers' perceptions of ChatGPT support across TPACK-related practices rather than evidence of changes in teachers' TPACK competence.

Comparison of Content Knowledge and Technological Knowledge

To further examine the observed difference between the highest-rated domain, CK, and the lowest-rated domain, TK, a Wilcoxon signed-rank test was conducted using the paired scores of the 109 teachers. The results showed a statistically significant difference between CK and TK scores, $Z = -3.716$, $p < .001$, $r = .356$, indicating a medium effect size. CK ($M = 3.51$, $SD = 0.89$, $Mdn = 3.58$) was significantly higher than TK ($M = 3.25$, $SD = 0.94$, $Mdn = 3.31$). This result confirms that the difference between CK and TK observed in the descriptive analysis is statistically meaningful rather than solely a difference in mean rankings. Thus, the higher perceived contribution of ChatGPT to CK compared with TK represents an important finding of the study.

DISCUSSION

This study sets out to explore the perceived contribution of ChatGPT to in-service teachers in terms of CK, PK, and technology knowledge, as conceptualized in the TPACK framework. The results, which were based on a sample of 109 in-service teachers mostly working in private schools with different curriculum packages, suggest a generally positive, though moderate-to-frequent, level of perceived contribution across all TPACK constructs ($M = 3.41$). The following section presents an interpretation of the findings in relation to the RQs and discusses their implications in light of existing literature on AI in education and the TPACK framework.

Technological Knowledge and ChatGPT (RQ1)

This RQ explored the level of in-service teachers' TK related to ChatGPT. Overall, the findings indicate that teachers possessed a moderate level of TK, suggesting that while ChatGPT has become part of their teaching practice, its use has not yet reached a level of confident and consistent integration. Although teachers were generally familiar with the tool ($M = 3.90$), their limited participation in formal training on ChatGPT and related AI technologies represents an important challenge to its effective classroom integration. This finding supports previous research suggesting that teachers often adopt emerging technologies through self-directed exploration rather than structured professional development (Mishra & Koehler, 2006; Niess, 2011). Consequently, professional development initiatives should focus not only on developing teachers' technological competence but also on strengthening AI literacy, including prompt design, critical evaluation of AI-generated content, and

the responsible and ethical use of GenAI in educational settings. The relatively high variability in teachers' responses further suggests that teachers differ considerably in their readiness to adopt AI technologies, reflecting the varying stages of technology adoption described by Rogers (2003).

ChatGPT's Perceived Contribution to Pedagogical Practices (RQ2)

RQ2 aimed to explore teachers' perceptions of ChatGPT support for pedagogical practices. Overall, teachers perceived ChatGPT as a useful tool for supporting pedagogical practices, particularly in lesson planning and future instructional activities. Teachers also expressed a strong willingness to continue using ChatGPT in their teaching, indicating a positive attitude toward integrating GenAI into classroom practice. However, their relatively limited participation in professional development related to ChatGPT suggests that this positive perception has not yet been fully supported by structured training opportunities. This is consistent with Crompton and Burke (2023), who noted that although teachers express enthusiasm for AI tools, they often lack the institutional support needed to translate this enthusiasm into effective classroom practice. This finding also aligns with the technology acceptance model (Davis, 1989), which proposes that positive perceptions of usefulness encourage technology adoption, while sustained and effective use depends on adequate training and perceived ease of use. Therefore, educational institutions should provide continuous professional development that equips teachers with pedagogical strategies and AI literacy skills for effective, responsible, and ethical use of ChatGPT.

ChatGPT's Support for Curriculum-Aligned Instructional Content (RQ3)

RQ3 sought to establish the extent to which ChatGPT supports teachers in developing instructional content that is accurate, reliable, and aligned with the curriculum. Among all TPACK domains, CK received the most positive evaluation, indicating that teachers perceive ChatGPT as particularly valuable for lesson planning and the development of curriculum-aligned instructional materials. The strongest perceived benefit was ChatGPT's contribution to lesson planning, highlighting its potential to support teachers in organizing and preparing instructional content efficiently. This finding is consistent with Kasneci et al. (2023), who reported that GenAI models, such as ChatGPT, can substantially facilitate instructional content development, idea generation, and scaffolding. However, teachers perceived ChatGPT as being less effective in supporting language differentiation for students with diverse learning abilities. This finding suggests that AI-generated content should be adapted to accommodate learner diversity rather than being used

without modification, which is a fundamental principle of universal design for learning (CAST, 2018). Therefore, while ChatGPT demonstrates considerable potential for supporting content preparation and lesson planning, teachers should critically review and adapt AI-generated materials to ensure they are inclusive, contextually appropriate, and responsive to the diverse needs of learners.

ChatGPT and Pedagogical Content Knowledge (RQ4)

RQ4 aims to assess the perceived contribution of ChatGPT to teachers' PCK in developing meaningful, interesting, and reflective learning activities. The findings indicate that teachers perceive ChatGPT as an effective tool for supporting PCK, particularly in designing learning activities that promote meaningful engagement with subject content. Teachers appeared to value ChatGPT more for supporting structured instructional approaches than for fostering creative and playful pedagogies. This finding is partially consistent with Shulman's (1986) original formulation of PCK as the integration of CK and pedagogy, which was later extended by Koehler and Mishra (2009) to incorporate TK. The comparatively lower rating for developing fun and playful learning activities suggests that, although ChatGPT is perceived as supporting instructional design, teachers continue to play a critical role in adapting AI-generated suggestions to create engaging, creative, and learner-centered experiences. This finding reinforces the view that GenAI should be regarded as a pedagogical support tool rather than a substitute for teachers' professional expertise and instructional creativity. The moderate variability in PCK ratings further indicates that teachers' ability to use ChatGPT effectively depends on their existing pedagogical and content expertise, a finding that is consistent with Selwyn's (2019) argument that AI tools augment rather than replace teachers' professional knowledge.

ChatGPT and Technological Pedagogical Knowledge and Technological Content Knowledge (RQ5 & RQ6)

RQ5 and **RQ6** explored the contribution of ChatGPT in assisting teachers with TPK and TCK, respectively. Overall, the findings indicate that teachers perceive ChatGPT as a valuable tool for integrating technology into both pedagogical practices and subject content. Teachers particularly valued ChatGPT's ability to recommend digital tools and resources that enrich instructional materials, highlighting its potential to support lesson preparation and technology-enhanced teaching. However, teachers perceived ChatGPT as less effective in supporting technologies that promote direct student interaction, suggesting that the tool currently has greater value for teacher-centered instructional planning than for facilitating student-centered learning experiences. This finding supports Ertmer and Ottenbreit-Leftwich's (2010) argument that effective

technology integration requires teachers to possess a deep understanding of how technology can be used to enhance teaching and learning. Similarly, the positive perceptions of TCK indicate that teachers view ChatGPT as an effective tool for aligning digital technologies with curriculum content, a finding that is consistent with Holmes et al. (2019). Nevertheless, maximizing the educational benefits of ChatGPT requires teachers to possess strong technological competence and pedagogical judgment so that AI-supported technologies can be integrated in ways that actively engage students rather than simply enrich teaching materials. These findings reinforce the importance of strengthening teachers' technological competence and AI literacy to promote more interactive, student-centered, and pedagogically meaningful uses of GenAI in education.

ChatGPT and the Comprehensive Integration of TPACK (RQ7)

RQ7 focused on the degree to which teachers perceive ChatGPT as supporting the comprehensive integration of TPACK into teachers' practices. The findings indicate that teachers generally perceive ChatGPT as an effective tool for supporting the integration of technology, pedagogy, and content within their instructional practices. Teachers particularly recognized ChatGPT's ability to align curriculum content, digital technologies, and pedagogical approaches during lesson planning and instructional design. From a theoretical perspective, these findings provide empirical support for Mishra and Koehler's (2006) TPACK framework, which emphasizes that effective technology integration depends on the dynamic interaction of TK, PK, and CK rather than on any single knowledge domain in isolation. The results suggest that ChatGPT can facilitate this integration by supporting teachers in connecting these knowledge domains during instructional planning. However, teachers perceived ChatGPT as less effective in promoting diverse instructional approaches, indicating that AI-generated recommendations may reinforce familiar teaching practices rather than encourage innovative pedagogy. This observation is consistent with Hughes et al. (2006), who argued that educational technologies should be used to transform teaching practices rather than simply replicate traditional instructional methods. Therefore, while ChatGPT demonstrates considerable potential for supporting comprehensive TPACK integration, its educational value ultimately depends on teachers' ability to apply professional judgment, creativity, and pedagogical expertise when adapting AI-generated recommendations to meet diverse learning needs.

Demographic Differences in Teachers' Perceptions of ChatGPT Support (RQ8)

RQ8 examined whether teachers' perceptions of ChatGPT support for TPACK-related practices differed according to gender, teaching experience, and academic qualification. The analyses found no statistically significant differences across the demographic groups examined (all $p > .05$). These non-significant findings should not be interpreted as evidence that the groups are equivalent; rather, they indicate that statistically significant group differences were not detected in this sample. The findings therefore provide preliminary support for considering institution-wide professional development, while allowing for contextual or individual differences in teachers' needs. These findings provide preliminary support for considering institution-wide professional development programs to strengthen teachers' effective and responsible use of GenAI in their teaching practices, while considering contextual and individual differences in teachers' needs, prior experience, and familiarity with GenAI.

Overall Discussion and Theoretical Implications

Overall, the findings of this study indicate that teachers perceived ChatGPT as providing positive support across all TPACK domains, suggesting that GenAI can support teachers in integrating technology, pedagogy, and content within their instructional practices. Among the TPACK domains, CK received the highest evaluation, suggesting that teachers perceive ChatGPT as particularly valuable for curriculum development, lesson planning, and instructional content preparation. In contrast, TK received the lowest evaluation, highlighting the need for greater support in developing teachers' technological competence for effective AI integration. These findings are consistent with the emerging literature that views GenAI as a transformative force in education (Baidoo-Anu & Ansah, 2023; Firat, 2023), while also emphasizing the importance of addressing the challenges associated with its implementation.

From a theoretical perspective, the research findings support the continued relevance of the TPACK framework for understanding teachers' use of GenAI in educational practice. The TPACK framework, proposed by Mishra and Koehler (2006), emphasizes that effective technology integration results from the dynamic interaction of TK, PK, and CK rather than from any individual knowledge domain. The present findings demonstrate that ChatGPT is perceived as supporting this interaction by assisting teachers in lesson planning, content development, and technology integration across multiple TPACK domains. However, the comparatively lower ratings for TK suggest that successful AI integration requires competencies that extend beyond traditional technology skills. Rather than indicating

limitations of the TPACK framework itself, these findings highlight the increasing importance of AI literacy as an integral component of teachers' technological competence. Recent studies have argued that effective AI integration requires competencies extending beyond technical use to include prompt design, verification of AI-generated content, and ethical decision making (Ng et al., 2021).

The difference between CK and TK provides an important empirical finding of this study. CK was the highest-scoring domain ($M = 3.51$), whereas TK was the lowest ($M = 3.25$). Importantly, the Wilcoxon signed-rank test confirmed that this difference was statistically significant ($Z = -3.716$, $p < .001$, $r = .356$), with a medium effect size. This finding indicates that teachers' perceived contribution of ChatGPT was significantly higher for CK than for TK. The result provides empirical support for the need to examine technological competence and AI literacy more closely when considering the integration of GenAI within the TPACK framework. Consistent with Celik (2023) and Lim et al. (2023), and Demir et al. (2026), the findings suggest that teachers' technological competence in the era of GenAI should include not only operational skills but also AI literacy, including prompt engineering, critical evaluation of AI-generated content, bias detection, and ethical decision making. Recent work on extended GenAI-TPACK further emphasizes competencies such as critical evaluation, prompt engineering, human-AI role sharing, ethics and social judgment, and student-AI interaction management as important considerations for teacher knowledge in GenAI contexts (Demir et al., 2026). Although the TPACK framework remains an appropriate theoretical lens for explaining technology integration, the findings indicate that AI literacy is becoming an increasingly important aspect of teachers' TK and should be incorporated into future teacher professional development and AI integration initiatives.

Practical Implications

The findings carry significant practical implications for school administrators, curriculum developers, and professional development designers. First, the substantial gap between general ChatGPT familiarity and formal pedagogical training highlights the need for structured professional development programs that move beyond basic tool awareness and focus on the effective pedagogical integration of GenAI into teaching and learning. Such programs should support teachers' AI literacy by strengthening their ability to formulate effective prompts, evaluate AI-generated responses, and integrate ChatGPT into curriculum planning and classroom instruction (Mollick & Mollick, 2023). Second, given the documented risks associated with AI-generated content, including hallucinations and algorithmic bias (Bender et al., 2021), professional development should prepare teachers to critically

evaluate AI-generated information, verify its accuracy using reliable sources, and identify potential bias before incorporating it into instructional materials. Third, data privacy and ethical AI use should form an essential component of teacher training. Teachers should understand the ethical and legal implications of using AI tools, particularly when handling student data and institutional information, in accordance with national and institutional policies (Miao & Holmes, 2023). Fourth, the comparatively lower ratings for differentiated instruction suggest that teachers require additional support in adapting AI-generated content to accommodate learners with diverse language abilities, learning preferences, and educational needs in line with universal design for learning principles (CAST, 2018). Fifth, the absence of demographic differences suggests that institution-wide AI professional development initiatives can be implemented for teachers regardless of gender, teaching experience, or academic qualification, thereby supporting consistent AI integration across the teaching workforce. Finally, the difference between CK and TK highlights the importance of strengthening teachers' technological competence alongside AI literacy. Professional development programs should therefore emphasize not only the technical use of AI tools but also ethical AI use, critical evaluation of AI-generated content, and responsible integration of GenAI into teaching practice.

Limitations

There are certain limitations to this study that need to be mentioned. Firstly, the sample was predominantly drawn from private schools (93.6%) in the UAE. Therefore, the findings should be interpreted with caution and may not be generalizable to teachers working in public schools or in other educational contexts and countries.

Secondly, the study relied on self-report measures, meaning that the data were based on teachers' perceptions and responses rather than direct observation of classroom practices or objective measures of teaching effectiveness. Consequently, the findings reflect teachers' perceived use and perceived support of ChatGPT rather than their actual classroom practices, and they may be affected by response biases such as social desirability or self-perception bias. A related construct-validity consideration is that some item wording may elicit perceptions of ChatGPT's capabilities in addition to perceptions of teachers' own knowledge, skills, and practices. The items were designed to prompt reflection on teachers' experiences and use of ChatGPT; nevertheless, the instrument should be understood as measuring perceived ChatGPT support for TPACK-related practices rather than objective TPACK competence. Future studies should incorporate classroom observations, interviews,

teaching artefacts, or performance-based measures to triangulate the findings.

A further limitation concerns the construct validity of the self-report instrumentation. Some item wording may elicit teachers' perceptions of ChatGPT's capabilities in addition to their perceptions of their own knowledge, skills, and practices. The items in this instrument were designed to prompt participants to reflect on their own knowledge, skills, and practices in the context of using ChatGPT (e.g., "How familiar are you with ..." and "To what extent did you use ChatGPT to ..."), rather than to assess ChatGPT itself. Nevertheless, some items may reflect teachers' perceptions of the tool's capabilities and its contribution to TPACK-related practices. Therefore, the findings should be interpreted as teachers' perceived contribution of ChatGPT to TPACK-related practices rather than as an objective assessment of their TPACK knowledge or competence. Future research should consider combining self-report measures with validated TPACK assessments, classroom observations, teaching artefacts, or performance-based measures to provide stronger evidence of teachers' TPACK competence.

Thirdly, the cross-sectional research design captured teachers' perceptions at a single point in time and therefore does not permit conclusions about causal relationships, effects of ChatGPT, or changes in TPACK competence over time. Future longitudinal studies are recommended to examine changes in teachers' AI-related TPACK competencies and instructional practices over time.

Finally, this study examined teachers' overall perceptions of ChatGPT without investigating how different educational tasks or instructional contexts influence their use. Future research should explore specific use cases of ChatGPT, such as lesson planning, assessment design, feedback generation, differentiated instruction, and curriculum development, to determine how these applications contribute to the development of different TPACK domains.

CONCLUSION

This study investigated teachers' perceptions of ChatGPT support for TPACK-related practices among in-service teachers in the UAE. The findings indicate positive perceived support across all seven TPACK domains, with the strongest perceived support observed in CK, particularly in lesson planning, curriculum alignment, and instructional content development. TK received the lowest ratings, suggesting a need for additional support in AI literacy and technological competence. The statistically significant difference between CK and TK ($Z = -3.716$, $p < .001$, $r = .356$) indicates that teachers perceived greater support from ChatGPT for CK than for TK in this sample. Because the study used a cross-sectional self-report design, this result should be interpreted as a difference in perceived

support rather than evidence that ChatGPT caused differences in teachers' TPACK competence. The absence of statistically significant demographic differences indicates that statistically significant group differences were not detected in this sample; it does not establish equivalence among the demographic groups. From a theoretical perspective, the findings support the usefulness of the TPACK framework for examining teachers' perceptions of GenAI-supported instructional practices while highlighting the growing importance of AI literacy within technological competence.

Recommendations

Based on the findings of this study, it is recommended that educational institutions provide continuous professional development programs designed to strengthen teachers' technological competence and AI literacy alongside their practical skills in using GenAI tools such as ChatGPT. These programs should address key areas such as effective prompt design, critical evaluation of AI-generated content, bias awareness, data privacy, and the ethical and responsible use of GenAI in educational settings (Miao & Holmes, 2023). Institution-wide professional development programs may be considered as a broad institutional strategy, while incorporating flexible and differentiated components that respond to teachers' specific instructional contexts, prior experience, and support needs.

Curriculum developers and policymakers should incorporate AI-related competencies into teacher professional development and curriculum guidelines to support the responsible integration of GenAI within the TPACK framework. Particular attention should be given to helping teachers adapt AI-generated content to accommodate diverse learner needs and promote inclusive teaching practices consistent with universal design for learning principles (CAST, 2018).

Future research should employ longitudinal and mixed-methods designs to examine how teachers' AI-related competencies develop over time. Comparative studies involving public and private schools, different educational systems, and diverse cultural contexts are also recommended. In addition, future research should investigate the relationship between teachers' AI competencies, classroom implementation of GenAI, and student learning outcomes to provide a more comprehensive understanding of AI-supported teaching and learning.

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