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Teaching in the Age of Artificial Intelligence: An Assessment of Technological Pedagogical Content Ethical Knowledge among Public Elementary School Teachers

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Abstract. This study investigated the perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) of public elementary school teachers to establish a basis for strengthening ethical technology integration in teaching. It specifically assessed teachers' perceived knowledge across eight dimensions: Ethical Knowledge, Pedagogical Ethical Knowledge, Content Ethical Knowledge, Technological Ethical Knowledge, Technological Pedagogical Ethical Knowledge, Technological Content Ethical Knowledge, Pedagogical Content Ethical Knowledge, and Technological Pedagogical Content Ethical Knowledge. It also examined significant differences according to age, highest educational attainment, and teaching experience and determined the interrelationships among these dimensions. Utilizing a quantitative, descriptive-comparative-correlational research design, data were gathered from 194 public elementary school teachers in Baliwasan District, Schools Division of Zamboanga City, through an adapted questionnaire using proportionate stratified random sampling. Results revealed a very high overall level of perceived TPCEK (M = 4.33), with Ethical Knowledge obtaining the highest mean (M = 4.48) and Content Ethical Knowledge the lowest (M = 4.23). Significant differences were found according to age, highest educational attainment, and teaching experience, although post-hoc comparisons indicated that these differences were limited to specific groups. Younger teachers, those with higher educational qualifications, and those with fewer years of teaching experience generally reported higher perceived TPCEK scores. Correlational analysis revealed significant positive relationships among all eight dimensions, suggesting that higher perceived knowledge in one dimension was associated with higher perceived knowledge in others. The findings highlight the importance of continuous professional development, particularly in strengthening ethical considerations related to subject content. However, the cross-sectional, self-report design did not establish actual classroom competence or causal relationships. The study recommends needs-based training and collaborative learning opportunities to support responsible technology integration. Future research should examine the relationship between perceived TPCEK and observed classroom practices.

Keywords: Ethical Knowledge; Pedagogical Ethical Knowledge; Content Ethical Knowledge; Technological Ethical Knowledge; Technological Pedagogical Content Ethical Knowledge (TPCEK)

Introduction

Artificial intelligence (AI) is transforming twenty-first-century education by influencing how instruction is planned, delivered, and assessed. Teachers increasingly utilize AI-powered technologies to develop lesson plans, prepare instructional materials, generate assessments, provide feedback, and support student learning. While these technologies offer opportunities to improve teaching efficiency and personalize learning experiences, their integration requires teachers to demonstrate sound professional judgment and ethical responsibility. According to Miao and Holmes (2023), AI should support rather than replace teachers while upholding human agency, equity, transparency, and responsible decision-making. Similarly, the Organisation for Economic Co-operation and Development (OECD, 2024) emphasizes the importance of

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strengthening critical thinking, creativity, ethical reasoning, and professional judgment alongside technological competencies.

Despite these opportunities, the increasing integration of AI in education presents challenges involving data privacy, intellectual property, algorithmic bias, misinformation, transparency, and academic integrity. Miao and Holmes (2023) emphasizes that teachers must remain accountable for ensuring the accuracy, appropriateness, and ethical use of AI-generated content in educational settings. Recognizing the need for competencies beyond technological proficiency, Deng and Zhang (2023) introduced the Technological Pedagogical Content Ethical Knowledge (TPCEK) framework, extending the Technological Pedagogical Content Knowledge (TPACK) framework by incorporating ethical knowledge into teachers' professional competencies. In the context of artificial intelligence, TPCEK extends beyond general ethical technology use by emphasizing teachers' knowledge of the ethical considerations associated with AI-supported instructional decisions, particularly the accuracy of AI-generated content, algorithmic bias, data privacy, transparency, and academic integrity. Unlike broader ethical technology competence, which addresses responsible technology use in general, AI-related TPCEK focuses on the interconnected knowledge required to make informed pedagogical, content-related, technological, and ethical decisions when using AI in teaching. Their development and validation of the TPCEK assessment instrument provide a basis for examining how teachers integrate technological, pedagogical, content, and ethical knowledge in instructional decision-making.

Although existing research has examined teachers' AI readiness, AI literacy, technology acceptance, digital competence, and self-efficacy, empirical studies focusing on TPCEK remain limited, particularly among in-service public elementary school teachers. This research gap is especially relevant in the Philippine basic education context, where the increasing adoption of AI technologies requires professional development initiatives that address both technological competence and ethical responsibility. However, evidence concerning teachers' perceived knowledge of the ethical dimensions of AI integration remains insufficiently established in the local context. While broader studies on technology integration provide insights into teachers' digital competencies, they do not necessarily explain how teachers perceive their knowledge of the interconnected ethical, pedagogical, content, and technological considerations involved in AI-supported instruction. This creates a need for context-specific evidence that can identify teachers' strengths and areas requiring professional development. In Baliwasan District, Schools Division of Zamboanga City, understanding teachers' TPCEK is essential for identifying their strengths, determining areas requiring improvement, and providing empirical evidence to support responsible AI integration and district-level professional development planning.

This study determined the level of Technological Pedagogical Content Ethical Knowledge (TPCEK) among public elementary school teachers in Baliwasan District, Schools Division of Zamboanga City, during the School Year 2026–2027. Specifically, it assessed teachers' perceived knowledge across the TPCEK dimensions, examined significant differences according to selected profile variables, and determined the interrelationships among these dimensions. The findings provided baseline evidence that could guide school administrators, the Schools Division Office, and other education stakeholders in developing responsive professional development programs that promote the ethical, responsible, and effective integration of artificial intelligence in basic education.

Research Questions

This study assessed the Technological Pedagogical Content Ethical Knowledge (TPCEK) of public elementary school teachers in Baliwasan District, Schools Division of Zamboanga City, in the context of teaching in the age of artificial intelligence during the School Year 2026–2027. Specifically, the study sought to answer the following questions:

1. What is the level of teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) in terms of:
   1.1 Ethical Knowledge (EK),
   1.2 Pedagogical Ethical Knowledge (PEK);
   1.3 Content Ethical Knowledge (CEK);
   1.4 Technological Ethical Knowledge (TEK);
   1.5 Technological Pedagogical Ethical Knowledge (TPEK);
   1.6 Technological Content Ethical Knowledge (TCEK);
   1.7 Pedagogical Content Ethical Knowledge (PCEK); and
   1.8 Technological Pedagogical Content Ethical Knowledge (TPCEK)?
2. Is there a significant difference in the teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to:
   2.1 Age,
   2.2 Highest Educational Attainment, and

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2.3 Teaching Experience

3. Is there a significant interrelationship among the dimensions of Technological Pedagogical Content Ethical Knowledge (TPCEK)?

Scope and Delimitation of the Study

This study assessed the Technological Pedagogical Content Ethical Knowledge (TPCEK) of public elementary school teachers in Baliwasan District, Schools Division of Zamboanga City, during the School Year 2026–2027. It focused on Ethical Knowledge, Pedagogical Ethical Knowledge, Content Ethical Knowledge, Technological Ethical Knowledge, Technological Pedagogical Ethical Knowledge, Technological Content Ethical Knowledge, Pedagogical Content Ethical Knowledge, and Technological Pedagogical Content Ethical Knowledge. It also examined differences according to age, highest educational attainment, and teaching experience, as well as the interrelationships among the dimensions. The study covered teachers from all public elementary schools in Baliwasan District, with participating schools assigned alphabetical codes to protect their identities and maintain anonymity in reporting the findings.

Literature Review

Artificial Intelligence in Education

Artificial intelligence (AI) has become an important development in education, influencing instructional planning, assessment, learner support, and educational decision-making. Its applications have evolved from intelligent tutoring systems and adaptive learning environments to generative AI technologies capable of producing instructional materials, assessments, and personalized learning resources (Chen et al., 2020; Lo, 2023; Tlili et al., 2023). AI-powered systems can also analyze learner performance, identify learning difficulties, and recommend individualized learning activities (Chen et al., 2020; Luckin & Cukurova, 2019). However, these capabilities do not automatically ensure improved learning outcomes. Teachers remain responsible for evaluating the accuracy, curriculum alignment, and appropriateness of AI-generated materials, emphasizing that effective integration requires more than technological proficiency.

Generative AI has further expanded opportunities for lesson preparation, differentiated instruction, assessment development, and feedback generation (Lo, 2023; Tlili et al., 2023). Despite these benefits, AI-generated outputs may contain inaccuracies, biases, or content that does not align with intended learning competencies. Their effective use therefore requires teachers to exercise professional judgment in determining whether the materials are academically accurate, pedagogically appropriate, and ethically acceptable. Teachers' engagement with AI is also influenced by professional development, confidence, trust, and institutional support (Cukurova et al., 2023; Nazaretsky et al., 2022). Nevertheless, confidence and willingness to adopt AI do not necessarily indicate sufficient professional knowledge. This distinction highlights the importance of examining teachers' knowledge rather than focusing exclusively on technology acceptance or readiness.

Ethical considerations are equally important in AI integration, particularly those involving algorithmic bias, data privacy, transparency, accountability, intellectual property, and academic integrity (Chaudhry et al., 2022; Nguyen et al., 2023). These concerns influence teachers' decisions when evaluating AI-generated information, protecting learners' personal data, and ensuring fairness in instructional activities. Consequently, technological knowledge must be accompanied by ethical judgment. However, awareness of ethical risks does not necessarily establish teachers' ability to address these concerns in instructional situations, suggesting the need for frameworks that integrate technological, pedagogical, content, and ethical knowledge.

Recent developments in educational technology frameworks have increasingly recognized ethical responsibility as an essential component of teachers' professional knowledge (Celik, 2023; Paidicán & Herrera, 2024). Celik (2023) developed the Intelligent-TPACK framework to examine teachers' knowledge of AI-based instruction, emphasizing the importance of pedagogical understanding and ethical assessment alongside technological knowledge. Similarly, Deng and Zhang (2023) introduced the Technological Pedagogical Content Ethical Knowledge (TPCEK) framework, which incorporates ethical knowledge into the interconnected dimensions of technological, pedagogical, and content knowledge. Unlike approaches that examine technological competence or ethical awareness separately, TPCEK provides eight dimensions for assessing teachers' perceived knowledge, including the relationships between ethical considerations and instructional practices, subject content, and technology integration.

Existing literature further demonstrates the importance of distinguishing AI adoption from professional knowledge. Nazaretsky et al. (2022) examined teachers' trust in AI-powered educational technology and the role of professional development in supporting its acceptance. In contrast, Celik (2023) focused on teachers' knowledge of AI-based instruction, indicating that technological knowledge alone was

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insufficient for effective integration. Although trust and confidence may encourage technology adoption, they do not establish whether teachers possess the knowledge required to evaluate AI-supported instructional decisions. Furthermore, while Celik (2023) specifically addressed AI-based educational tools, Deng and Zhang (2023) developed and validated the broader TPCEK framework among preservice teachers. These differences suggest that AI-specific ethical knowledge and broader ethical technology knowledge are related but distinct concepts.

Teacher Competence in the Age of Artificial Intelligence

The advancement of artificial intelligence (AI) has expanded teachers' professional responsibilities beyond traditional subject content, pedagogy, and classroom management. Teachers are increasingly expected to understand AI technologies, evaluate their instructional applications, and recognize their ethical implications. The AI Competency Framework for Teachers identifies human-centered thinking, AI ethics, AI foundations and applications, AI pedagogy, and professional learning as essential areas of teacher development (Miao & Cukurova, 2024). Similarly, existing literature emphasizes that effective AI integration requires the combination of technological and pedagogical knowledge with professional judgment (Luckin & Cukurova, 2019; Holmes et al., 2022; Cukurova et al., 2023). Thus, teachers' competence involves not only using AI applications but also making informed decisions about their educational value.

Existing studies distinguish teachers' willingness to adopt AI from their professional knowledge. Nazaretsky et al. (2022) examined teachers' trust in AI-powered educational technologies and the role of professional development in supporting their acceptance. In contrast, Celik (2023) investigated technological, pedagogical, and ethical knowledge, emphasizing that technological knowledge alone was insufficient for effective AI integration. These findings suggest that confidence and trust may encourage AI adoption but do not necessarily indicate the knowledge required to evaluate AI-supported instructional decisions. This distinction highlights the importance of assessing teachers' interconnected professional knowledge rather than focusing solely on technology acceptance.

The relevance of interconnected knowledge is further supported by research on Technological Pedagogical Content Knowledge (TPACK). Paidicán and Herrera (2024) discussed its application to AI integration, while Saharuddin et al. (2025) examined TPACK among in-service primary school teachers in Sabah, Malaysia. Although the latter reported high levels of TPACK, significant age-related differences were observed in selected dimensions, but not in technological content and technological pedagogical knowledge. These findings indicate that teachers' knowledge may vary across dimensions and demographic groups without establishing that age or teaching experience determines overall competence.

Another important distinction concerns AI literacy and teachers' professional knowledge for instructional integration. AI literacy involves understanding AI concepts, applications, limitations, and ethical implications (Ng et al., 2021). However, teachers must also evaluate whether AI-generated materials are accurate, developmentally appropriate, and aligned with curriculum objectives. Since generative AI may produce inaccurate information, biased responses, or fabricated content, its instructional use requires critical evaluation (Lo, 2023; Tlili et al., 2023). Consequently, understanding AI does not automatically establish sufficient knowledge for its appropriate integration into teaching.

Ethical responsibility is particularly important because AI integration raises concerns involving data privacy, transparency, algorithmic bias, intellectual property, and academic integrity. Miao and Cukurova (2024) identify AI ethics as an essential dimension of teacher competence, while Celik (2023) emphasizes ethical assessment in AI-supported instruction. Although both recognize the importance of ethics, their approaches differ. The former provides a competency framework for teacher development, whereas the latter examines relationships among knowledge dimensions. These perspectives reinforce the need to assess how ethical knowledge relates to teachers' technological, pedagogical, and content knowledge.

Building on this perspective, Deng and Zhang (2023) developed the Technological Pedagogical Content Ethical Knowledge (TPCEK) framework and validated an instrument among preservice teachers. Unlike approaches that examine ethical awareness separately, TPCEK incorporates ethical knowledge into the interconnected dimensions of technological, pedagogical, and content knowledge. While Celik (2023) focused specifically on AI-based instructional technologies through Intelligent-TPACK, Deng and Zhang (2023) provided a broader framework for examining ethical knowledge in educational technology integration. The present study adopts TPCEK to assess teachers' perceived knowledge across its eight dimensions.

Technological Pedagogical Content Knowledge (TPACK)

The Technological Pedagogical Content Knowledge (TPACK) framework provides a theoretical foundation for understanding teachers' professional knowledge in technology-supported instruction. Building on Shulman's (1986) concept of Pedagogical Content Knowledge (PCK), Mishra and Koehler (2006) emphasized that effective technology integration requires the interconnected application of technological,

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pedagogical, and content knowledge. The framework consists of three core domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), and four intersecting domains: Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK). These dimensions explain how teachers integrate technology according to instructional objectives, subject requirements, and learners' needs (Mishra & Koehler, 2006; Koehler et al., 2013).

The relevance of TPACK has been examined across educational contexts. Valtonen et al. (2017) explored its application in teacher education, while Sofwan et al. (2024) discussed its continuing importance in technology integration research. Similarly, Zeng et al. (2018) examined the relationship between TPACK and technology integration, while Chai et al. (2013) emphasized integrated knowledge in designing learner-centered instruction. These studies support the importance of connecting technological proficiency with pedagogical approaches and subject content rather than treating technology as an independent instructional component.

Professional development also plays an important role in strengthening TPACK. Authentic instructional design experiences, collaborative learning, and sustained professional development can support teachers in developing interconnected knowledge through practical application (Koehler et al., 2014; Chai et al., 2020). However, technological proficiency does not necessarily indicate equivalent pedagogical or content-related knowledge. This distinction supports examining individual and intersecting knowledge dimensions rather than relying solely on an overall assessment of teachers' technological competence.

The emergence of artificial intelligence (AI) has introduced additional considerations in applying TPACK to contemporary education. Paidicán and Herrera (2024) discussed its relevance to AI-supported instruction, while Saharuddin et al. (2025) identified differences in selected TPACK dimensions and demographic characteristics among primary school teachers. These findings suggest that teachers' professional knowledge may vary across dimensions and groups. However, traditional TPACK primarily addresses the integration of technology, pedagogy, and content without explicitly identifying ethical knowledge as a separate dimension.

This limitation is particularly relevant as AI introduces concerns involving data privacy, algorithmic bias, transparency, academic integrity, and the accuracy of generated information. Celik (2023) addressed these concerns through the Intelligent-TPACK framework, emphasizing ethical assessment alongside technological and pedagogical knowledge. Similarly, Paidicán and Herrera (2024) highlighted emerging professional responsibilities associated with AI integration. Although TPACK remains an important foundation for understanding technology-supported instruction, these developments demonstrate the need to examine ethical considerations more explicitly.

Technological Pedagogical Content Ethical Knowledge (TPCEK)

The increasing integration of artificial intelligence (AI) into education has introduced ethical concerns beyond the traditional domains of technological, pedagogical, and content knowledge. Although the Technological Pedagogical Content Knowledge (TPACK) framework explains technology integration in teaching, it does not explicitly recognize ethical knowledge as a separate dimension. AI-supported instruction raises concerns involving data privacy, algorithmic bias, transparency, accountability, and academic integrity, emphasizing the need to integrate ethical responsibility into teachers' professional knowledge (Celik, 2023; Holmes et al., 2022; Miao & Cukurova, 2024).

To address these concerns, Deng and Zhang (2023) developed the Technological Pedagogical Content Ethical Knowledge (TPCEK) framework as an extension of TPACK. The framework incorporates ethical knowledge and its relationships with technology, pedagogy, and subject content. Although developed for educational technology integration more broadly, TPCEK is relevant to AI-supported instruction because it emphasizes teachers' understanding of the ethical implications of instructional decisions (Deng & Zhang, 2023).

The TPCEK framework consists of eight interconnected dimensions. Ethical Knowledge (EK) refers to teachers' understanding of ethical principles and professional responsibilities. Pedagogical Ethical Knowledge (PEK) concerns ethical considerations in instructional methods, while Content Ethical Knowledge (CEK) addresses ethical issues related to subject matter. Technological Ethical Knowledge (TEK) focuses on the responsible use of educational technologies, including privacy and fairness. Technological Pedagogical Ethical Knowledge (TPEK) involves the ethical integration of technology into instructional strategies, while Technological Content Ethical Knowledge (TCEK) addresses ethical considerations when technology is applied to specific subject content. Pedagogical Content Ethical Knowledge (PCEK) concerns ethical principles in subject-specific instruction, whereas Technological Pedagogical Content Ethical Knowledge (TPCEK) represents the integration of all four knowledge areas (Deng & Zhang, 2023).

The importance of ethical knowledge is further supported by research on AI integration. Celik (2023) developed the Intelligent-TPACK framework, emphasizing ethical assessment alongside technological and

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pedagogical knowledge, while Paidicán and Herrera (2024) examined TPACK in AI-supported education. Although these approaches recognize the importance of integrated professional knowledge, they differ in scope. Intelligent-TPACK focuses specifically on AI-based instructional technologies, whereas TPCEK provides a broader framework for examining ethical knowledge across technological, pedagogical, and content dimensions. This distinction indicates that AI-specific knowledge and broader ethical technology knowledge are related but should not be treated as identical constructs.

Teachers' professional knowledge may also vary according to their characteristics and experiences. Saharuddin et al. (2025) identified differences in selected TPACK dimensions among primary school teachers, suggesting that professional knowledge may not develop uniformly across demographic groups. However, these differences do not necessarily indicate corresponding variations in ethical knowledge. Furthermore, the importance of ethical assessment and responsible decision-making in AI-supported education has been emphasized in existing literature (Celik, 2023; Miao & Cukurova, 2024). These findings support examining ethical knowledge alongside technological, pedagogical, and content knowledge rather than assuming that technological proficiency ensures responsible integration.

Methodology

Research Design

This study employed a quantitative, descriptive-comparative-correlational research design to assess the Technological Pedagogical Content Ethical Knowledge (TPCEK) of public elementary school teachers in Baliwasan District, Schools Division of Zamboanga City, during the School Year 2026–2027. According to Creswell (2014), quantitative research involves the systematic collection and analysis of numerical data to describe variables, examine differences, and determine relationships among them. The descriptive component assessed teachers' TPCEK across eight dimensions: Ethical Knowledge, Pedagogical Ethical Knowledge, Content Ethical Knowledge, Technological Ethical Knowledge, Technological Pedagogical Ethical Knowledge, Technological Content Ethical Knowledge, Pedagogical Content Ethical Knowledge, and Technological Pedagogical Content Ethical Knowledge. The comparative component examined significant differences in teachers' TPCEK according to age, highest educational attainment, and teaching experience, while the correlational component determined the interrelationships among the eight dimensions. This research design was appropriate as it allowed the systematic assessment of teachers' competencies through numerical data and statistical analysis without manipulating the variables under investigation. The findings were intended to provide empirical evidence that could guide professional development initiatives and strengthen the ethical and responsible integration of artificial intelligence in public elementary education.

Research Locale

The study was conducted in Baliwasan District, Schools Division of Zamboanga City, Philippines, during the School Year 2026–2027. The district comprises public elementary schools serving different communities within Zamboanga City. The respondents were public elementary school teachers from the district, with a total population of 389 teachers, of whom 194 were selected through proportionate stratified random sampling. The study profiled teachers according to age, highest educational attainment, and teaching experience, examined significant differences and interrelationships among the TPCEK dimensions, and assessed their perceived ethical knowledge in integrating artificial intelligence into teaching and learning.

Research Participants

The study involved 194 public elementary school teachers selected from a population of 389 in Baliwasan District, Schools Division of Zamboanga City, during School Year 2026–2027 through proportionate stratified random sampling. Participation was voluntary, and only eligible teachers with valid questionnaires were included. Respondents were classified according to age, highest educational attainment, and teaching experience. The largest groups were teachers aged 31–40 years (78), those with master's units (71), and those with 6–10 years of teaching experience (67). Participating schools were assigned alphabetical codes to protect their identities in reporting the findings.

Research Instrument

The study utilized an adapted Technological Pedagogical Content Ethical Knowledge (TPCEK) Assessment Instrument developed by Deng and Zhang (2023). Part I gathered respondents' age, highest educational attainment, and teaching experience. Part II contained 30 items across eight dimensions: Ethical Knowledge (4), Pedagogical Ethical Knowledge (3), Content Ethical Knowledge (3), Technological Ethical Knowledge (3), Technological Pedagogical Ethical Knowledge (5), Technological Content Ethical Knowledge (3), Pedagogical Content Ethical Knowledge (4), and Technological Pedagogical Content Ethical Knowledge

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(5). Responses were measured using a five-point Likert scale ranging from 1 (Highly Disagree) to 5 (Highly Agree), with higher mean scores indicating higher perceived TPCEK. The original instrument demonstrated satisfactory reliability, with Cronbach's alpha coefficients ranging from .741 to .888 (Deng & Zhang, 2023). Selected items were contextually adapted for Philippine public elementary school teachers while retaining the original dimensions and scoring structure. The original developers were properly acknowledged, and adaptation and reuse were subject to the applicable licensing terms. Data collection followed institutional permission requirements and the Data Privacy Act of 2012 (Republic Act No. 10173).

Data Gathering Procedure

The researcher first secured approval from the Research Adviser, followed by permission from the Schools Division Office of Zamboanga City, Public Schools District Supervisor, and participating school heads. The adapted TPCEK Assessment Instrument underwent expert validation and pilot testing before data collection. Respondents were selected through proportionate stratified random sampling, and the researcher personally administered the questionnaires during teachers' available time without disrupting classes. Informed consent was obtained before participation, emphasizing confidentiality, voluntary participation, and the right to withdraw without penalty. Completed questionnaires were retrieved, checked for completeness, and screened for missing responses before encoding and statistical analysis.

Results and Discussions

Research Question 1: What is the level of teachers' Knowledge in terms of Ethical Knowledge (EK), Pedagogical Ethical Knowledge (PEK), Content Ethical Knowledge (CEK), Technological Ethical Knowledge (TEK), Technological Pedagogical Ethical Knowledge (TPEK), Technological Content Ethical Knowledge (TCEK), Pedagogical Content Ethical Knowledge (PCEK), and Technological Pedagogical Content Ethical Knowledge (TPCEK)?

Table 1. Level of teachers' Ethical Knowledge (EK)

Statements	Mean	Verbal Description	Interpretation
1. Even without the constraints of corresponding ethical principles, I know what kind of actions are morally inevitable.	4.38	Very High	Very Highly Knowledgeable
2. I know how to deal with ethical dilemmas that I faced and act ethically, even if there are difficulties.	4.51	Very High	Very Highly Knowledgeable
3. I can make moral reasoning and ethical decision-making based on ethical principles, and put them into action.	4.46	Very High	Very Highly Knowledgeable
4. I can evaluate and reflect on my ethical practice, ethical inference, and ethical decision-making.	4.57	Very High	Very Highly Knowledgeable
Over-all Mean	**4.48**	**Very High**	**Very Highly Knowledgeable**

Table 1 shows that teachers had a Very High level of Ethical Knowledge (EK), with an overall mean of 4.48, indicating that they considered themselves Very Highly Knowledgeable. The highest mean of 4.57 was recorded for their ability to reflect on ethical practices and decisions, while the lowest mean of 4.38 was obtained for recognizing morally appropriate actions even without established ethical guidelines. These results suggest that teachers were confident in their ability to make ethical decisions and reflect on their professional practices. This is consistent with studies emphasizing that ethical knowledge is important in helping teachers make responsible decisions when using technology in education (Deng & Zhang, 2023; Celik, 2023). Other studies also highlighted the need for teachers to understand issues involving fairness, privacy, transparency, and accountability when using artificial intelligence in the classroom (Chaudhry & Kazim, 2022; Nguyen et al., 2023; Miao & Cukurova, 2024). Although the results were generally high, continued professional development would help teachers strengthen their ethical judgment and apply it confidently in actual teaching situations.

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Table 2. Level of teachers' Pedagogical Ethical Knowledge (PEK)

Statements	Mean	Verbal Description	Interpretation
1. I think that teaching is a kind of ethical practice.	4.62	Very High	Very Highly Knowledgeable
2. I can identify the ethical issues in teaching, and make rational decision-making.	4.28	Very High	Very Highly Knowledgeable
3. I can promote ethical education in teaching practice.	4.41	Very High	Very Highly Knowledgeable
Over-all Mean	**4.44**	**Very High**	**Very Highly Knowledgeable**

Table 2 shows that teachers had a Very High level of Pedagogical Ethical Knowledge (PEK), with an overall mean of 4.44, indicating that they were Very Highly Knowledgeable. The highest mean of 4.62 was recorded for recognizing teaching as an ethical practice, while the lowest mean of 4.28 was obtained for identifying ethical issues in teaching and making rational decisions. The statement concerning the promotion of ethical education in teaching practice obtained a mean of 4.41, indicating that teachers also perceived themselves as highly knowledgeable in incorporating ethical principles into their instruction. These findings suggest that teachers recognized the ethical responsibilities associated with their profession and their role in promoting ethical education, although their comparatively lower rating in ethical decision-making suggests an area for further professional development. This supports the view that teaching involves moral responsibilities that extend beyond delivering lessons, particularly in ensuring fairness, respect, and learners' well-being (Campbell, 2003; Sockett, 1993). Similarly, ethical decision-making requires teachers to consider the consequences of their actions and balance professional responsibilities with learners' needs (Shapira-Lishchinsky, 2011). The results highlight the importance of providing opportunities for teachers to discuss real classroom dilemmas and strengthen their ethical judgment in everyday teaching.

Table 3. Level of teachers' Content Ethical Knowledge (CEK)

Statements	Mean	Verbal Description	Interpretation
1. I have sufficient ethical knowledge about my teaching subject.	4.32	Very High	Very Highly Knowledgeable
2. I can use the ethical reasoning method in my teaching subject.	4.12	High	Highly Knowledgeable
3. I know how to improve my understanding of the ethical issues of my teaching subject.	4.26	Very High	Very Highly Knowledgeable
Over-all Mean	**4.23**	**Very High**	**Very Highly Knowledgeable**

Table 3 shows that teachers had a Very High level of Content Ethical Knowledge (CEK), with an overall mean of 4.23, indicating that they were Very Highly Knowledgeable. The highest mean of 4.32 was recorded for having sufficient ethical knowledge about their teaching subjects, while the lowest mean of 4.12 was obtained for applying ethical reasoning within their subject areas, which was rated High. These findings suggest that teachers were confident in their understanding of subject-related ethical issues but were relatively less confident in applying ethical reasoning during instruction. This is consistent with the view that teachers need to connect their subject knowledge with appropriate pedagogical and ethical considerations to support meaningful learning (Shulman, 1986; Mishra & Koehler, 2006). Moreover, ethical considerations in education require teachers to examine how instructional content and emerging technologies may affect learners, particularly in relation to fairness, accuracy, and responsible information use (Holmes et al., 2022). The findings highlight the importance of strengthening teachers' ability to apply ethical reasoning within their respective teaching subjects.

Table 4. Level of teachers' Technological Ethical Knowledge (TEK)

Statements	Mean	Verbal Description	Interpretation
1. I think that the application of information technology can contribute to maintaining social fairness and justice.	4.35	Very High	Very Highly Knowledgeable
2. I tend to accept the application of information technology.	4.48	Very High	Very Highly Knowledgeable
3. I believe that the application of information technology does not violate conventional agreements or promises.	4.09	High	Highly Knowledgeable
Over-all Mean	**4.31**	**Very High**	**Very Highly Knowledgeable**

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Table 4 shows that teachers had a Very High level of Technological Ethical Knowledge (TEK), with an overall mean of 4.31, indicating that they were Very Highly Knowledgeable. The highest mean of 4.48 was recorded for their acceptance of information technology, while the lowest mean of 4.09, interpreted as High, was associated with their belief that the application of information technology does not violate conventional agreements or promises. These findings suggest that teachers generally held positive views toward technology integration, although their comparatively lower rating regarding compliance with existing agreements and commitments suggests a need for greater awareness of the ethical responsibilities associated with technology use. This relates to studies emphasizing that responsible technology integration requires teachers to consider ethical issues alongside technological competence, particularly regarding fairness, privacy, transparency, and accountability (Celik, 2023; Nguyen et al., 2023). Furthermore, teachers need appropriate guidance and professional preparation to evaluate the ethical implications of emerging technologies and make informed decisions about their classroom use (Holmes et al., 2022; Miao & Cukurova, 2024). The findings highlight the importance of strengthening teachers' technological ethical knowledge to support responsible and equitable technology integration in education.

Table 5. Level of teachers' Technological Pedagogical Ethical Knowledge (TPEK)

Statements	Mean	Verbal Description	Interpretation
1. I tend to accept the application of information technology.	4.43	Very High	Very Highly Knowledgeable
2. I know how to protect the physical and mental health of students in the use of a technology-enhanced learning environment.	4.27	Very High	Very Highly Knowledgeable
3. I know how to prevent students from internet addiction when teaching online.	4.08	High	Highly Knowledgeable
4. I can protect students' right to fair and equal use of the latest information technology in teaching practice.	4.19	High	Highly Knowledgeable
5. I can guide students to use online educational technologies and resources appropriately and ethically.	4.46	Very High	Very Highly Knowledgeable
Over-all Mean	**4.29**	**Very High**	**Very Highly Knowledgeable**

Table 5 shows that teachers had a Very High level of Technological Pedagogical Ethical Knowledge (TPEK), with an overall mean of 4.29, indicating that they were Very Highly Knowledgeable. The highest mean of 4.46 was recorded for guiding students in the appropriate and ethical use of online educational technologies, while the lowest mean of 4.08 was obtained for preventing internet addiction during online instruction, which was rated High. These findings suggest that teachers were confident in promoting responsible technology use but were relatively less confident in managing the risks associated with prolonged online engagement. This is consistent with studies emphasizing that effective technology integration requires teachers to consider learners' safety, well-being, and ethical responsibilities alongside instructional objectives (Deng & Zhang, 2023; Holmes et al., 2022). Furthermore, teachers need appropriate competencies to promote safe, inclusive, and responsible digital learning environments (Celik, 2023; Miao & Cukurova, 2024). The results highlight the importance of strengthening teachers' strategies for preventing excessive technology use and ensuring equitable access to digital learning resources.

Table 6. Level of teachers' Technological Content Ethical Knowledge (TCEK)

Statements	Mean	Verbal Description	Interpretation
1. I can use technology to enhance the representation of the content and concepts of my teaching subject in a manner consistent with ethical principles.	4.36	Very High	Very Highly Knowledgeable
2. I will use genuine software when creating and using a technological solution for my teaching subject.	4.18	High	Highly Knowledgeable
3. I know which ethical principles should be followed in the application of digital educational resources to my teaching subject	4.27	Very High	Very Highly Knowledgeable
Over-all Mean	**4.27**	**Very High**	**Very Highly Knowledgeable**

Table 6 shows that teachers had a Very High level of Technological Content Ethical Knowledge (TCEK), with an overall mean of 4.27, indicating that they were Very Highly Knowledgeable. The highest mean of 4.36 was recorded for using technology to present subject content in accordance with ethical

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principles, while the lowest mean of 4.18 was obtained for using genuine software in developing instructional materials, which was rated High. These findings suggest that teachers were confident in using technology responsibly to support subject instruction, although greater attention may be needed in promoting the use of properly licensed digital resources. This is consistent with literature emphasizing that effective technology integration requires teachers to align digital tools with subject content while considering their ethical implications (Mishra & Koehler, 2006; Deng & Zhang, 2023). Furthermore, responsible technology use involves respecting intellectual property, ensuring the accuracy of digital information, and protecting learners from potential risks associated with educational technologies (Holmes et al., 2022; Miao & Cukurova, 2024). The results highlight the importance of strengthening teachers' awareness of software licensing and responsible digital resource selection to support ethical technology integration in classroom instruction.

Table 7. Level of teachers' Pedagogical Content Ethical Knowledge (PCEK)

Statements	Mean	Verbal Description	Interpretation
1. I can deal with the problem of subject knowledge that can easily lead to confusion and even wrong values among students.	4.16	High	Highly Knowledgeable
2. I can treat different theories, thoughts, and viewpoints objectively and fairly in my teaching subject.	4.38	Very High	Very Highly Knowledgeable
3. I can treat students fairly and impartially in my teaching subject.	4.61	Very High	Very Highly Knowledgeable
4. I can encourage students to commit to the benefit of all mankind and society by using their subject matter expertise in the future in my subject teaching.	4.29	Very High	Very Highly Knowledgeable
Over-all Mean	**4.36**	**Very High**	**Very Highly Knowledgeable**

Table 7 shows that teachers had a Very High level of Pedagogical Content Ethical Knowledge (PCEK), with an overall mean of 4.36, indicating that they were Very Highly Knowledgeable. The highest mean of 4.61 was recorded for treating students fairly and impartially, while the lowest mean of 4.16 was obtained for addressing subject knowledge that could cause confusion or promote inappropriate values among learners, which was rated High. These findings suggest that teachers placed considerable importance on fairness and equal treatment but were relatively less confident in addressing sensitive or potentially misleading subject content. This is consistent with literature emphasizing that teaching involves ethical responsibilities, particularly in promoting fairness, respect, and sound professional judgment (Campbell, 2003; Shapira-Lishchinsky, 2011). Moreover, effective instruction requires teachers to consider how subject content is presented and understood while maintaining appropriate pedagogical and ethical standards (Shulman, 1986; Deng & Zhang, 2023). The findings highlight the importance of strengthening teachers' ability to address misconceptions and ethical concerns within their subject areas while maintaining fair and inclusive classroom practices.

Table 8. Level of teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK)

Statements	Mean	Verbal Description	Interpretation
1. I can teach lessons that appropriately combine my teaching subjects, technologies, teaching approaches, and ethics.	4.31	Very High	Very Highly Knowledgeable
2. I can use technology ethically in my subject teaching to enhance my teaching content and teaching approaches.	4.42	Very High	Very Highly Knowledgeable
3. I can use strategies that combine content, technologies, ethics, and teaching approaches in my classroom.	4.26	Very High	Very Highly Knowledgeable
4. I can provide leadership in helping others to coordinate the use of content, ethics, technology, and teaching approaches at my school and/or district.	4.08	High	Highly Knowledgeable
5. I can choose technologies that enhance the content of a lesson based on ethical principles.	4.35	Very High	Very Highly Knowledgeable
Over-all Mean	**4.28**	**Very High**	**Very Highly Knowledgeable**

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Table 8 shows that teachers had a Very High level of Technological Pedagogical Content Ethical Knowledge (TPCEK), with an overall mean of 4.28, indicating that they were Very Highly Knowledgeable. The highest mean of 4.42 was recorded for using technology ethically to improve subject content and teaching approaches, while the lowest mean of 4.08 was obtained for providing leadership in helping others integrate technology, pedagogy, content, and ethics, which was rated High. These findings suggest that teachers were confident in their ability to integrate technology responsibly into their own teaching but were relatively less confident in guiding their colleagues toward similar practices. This is consistent with studies emphasizing that effective technology integration requires a combination of technological, pedagogical, content, and ethical knowledge rather than technological skills alone (Deng & Zhang, 2023; Celik, 2023). Furthermore, collaborative professional learning and continuous training are important in developing teachers' competence and confidence in technology-supported instruction (Koehler et al., 2014; Paidicán & Herrera, 2024). The findings highlight the need to strengthen teacher leadership, mentoring, and collaborative learning opportunities to support the responsible integration of technology across schools.

Table 9. Summary of Teachers' Perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) Across Eight Dimensions

Indicators	Mean	Interpretation
1. Ethical Knowledge	4.48	Very Highly Knowledgeable
2. Pedagogical Ethical Knowledge	4.44	Very Highly Knowledgeable
3. Content Ethical Knowledge	4.23	Very Highly Knowledgeable
4. Technological Ethical Knowledge	4.31	Very Highly Knowledgeable
5. Technological Pedagogical Ethical Knowledge	4.29	Very Highly Knowledgeable
6. Technological Content Ethical Knowledge	4.27	Very Highly Knowledgeable
7. Pedagogical Content Ethical Knowledge	4.36	Very Highly Knowledgeable
8. Technological Pedagogical Content Ethical Knowledge	4.28	Very Highly Knowledgeable
Over-All Mean	**4.33**	**Very Highly Knowledgeable**

Table 9 presents the summary of teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) across eight dimensions, with an overall mean of 4.33, interpreted as Very Highly Knowledgeable. Ethical Knowledge obtained the highest mean of 4.48, followed by Pedagogical Ethical Knowledge (4.44), while Content Ethical Knowledge recorded the lowest mean of 4.23. The results indicate that teachers perceived themselves as more knowledgeable about ethical principles and their responsibilities in teaching than about applying ethical considerations to specific subject areas. This finding relates to the importance of integrating ethical knowledge with technology, pedagogy, and subject content to support responsible teaching practices (Deng & Zhang, 2023; Celik, 2023). Studies have also emphasized that teachers need to consider fairness, accountability, and learner protection when using digital technologies in instruction (Holmes et al., 2022; Miao & Cukurova, 2024). Although all eight dimensions received Very Highly Knowledgeable interpretations, the comparatively lower mean in Content Ethical Knowledge suggests a need for professional learning activities that help teachers address ethical issues within the subjects they teach.

Research Question 2: Is there a significant difference in the teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to Age, Highest Educational Attainment, and Teaching Experience?

Table 10. Significant difference in the teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) in terms of Age

Variable	Age	N	Mean	df	f-value	p-value	Effect Size (η^2)	Interpretation
1. TPCEK and Age	30 years old and below	45	4.43	3	3.21	.024	.048	Significant
	31–40 years old	78	4.36	190				
	41–50 years old	52	4.26	193				
	51 years old and above	19	4.15					
	Total	**194**	**4.33**					

Table 10 shows a significant difference in teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to age, as indicated by $F(3, 190) = 3.21$, $p = .024$, and an effect size (η^2) of .048, indicating a small effect. This suggests that approximately 4.8% of the variation in teachers' perceived TPCEK scores was associated with differences among age groups. Teachers aged 30 years and below obtained the highest mean of 4.43, while those aged 51 years and above recorded the lowest mean

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of 4.15. The results suggest that younger teachers tended to report higher perceived TPCEK scores than older teachers, although the differences between specific age groups require further examination through post-hoc comparisons. This finding is consistent with research indicating that teachers' technological knowledge and readiness to integrate artificial intelligence may vary according to age (Saharuddin et al., 2025). Related studies also emphasized that teachers' competence in using emerging technologies is shaped by their professional knowledge, confidence, and opportunities for training (Nazaretsky et al., 2022; Paidicán & Herrera, 2024). These findings suggest that differences in TPCEK should not be attributed to age alone, as exposure to technology and professional learning opportunities may also play important roles.

Table 10.1. Post hoc analysis of teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) in terms of Age

Variables	Age Group (I)	Age Group (J)	Mean Difference (I–J)	p-value
1. TPCEK	30 years old and below	31–40 years old	.070	.812
		41–50 years old	.170	.087
		51 years old and above	.280*	.019
	31–40 years old	30 years old and below	–.070	.812
		41–50 years old	.100	.451
		51 years old and above	.210*	.048
	41–50 years old	30 years old and below	–.170	.087
		31–40 years old	–.100	.451
		51 years old and above	.110	.382
	51 years old and above	30 years old and below	–.280*	.019
		31–40 years old	–.210*	.048
		41–50 years old	–.110	.382

Table 10.1 presents the post hoc analysis of teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to age. Significant differences were observed between teachers aged 30 years and below and those aged 51 years and above (p = .019), with a mean difference of .280, and between teachers aged 31–40 years and those aged 51 years and above (p = .048), with a mean difference of .210. The remaining comparisons showed no significant differences. These results suggest that teachers in the younger age groups reported higher perceived TPCEK scores than those aged 51 years and above. This finding is consistent with research indicating that age may be associated with differences in teachers' technological knowledge and readiness to integrate emerging technologies (Saharuddin et al., 2025). However, teachers' confidence and competence may also be influenced by their exposure to educational technologies and opportunities for professional development (Nazaretsky et al., 2022; Chai et al., 2013). The findings suggest the importance of providing professional learning opportunities that address teachers' varying technological experiences and support the development of TPCEK across age groups.

Table 11. Significant difference in the teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) in terms of Highest Educational Attainment

Variable	Highest Educational Attainment	N	Mean	df	f-value	p-value	Effect Size (η^2)	Interpretation
1. TPCEK and Highest Educational Attainment	Bachelor's Degree	40	4.13	3	4.27	.006	.063	Significant
	With Master's Units	71	4.27	190				
	Master's Degree	53	4.43	193				
	With Doctoral Units / Doctoral Degree	30	4.51					
	Total	**194**	**4.33**					

Table 11 shows a significant difference in teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to highest educational attainment, as indicated by $F(3, 190) = 4.27$, $p = .006$, and an effect size (η^2) of .063, indicating a small-to-moderate effect. This suggests that approximately 6.3% of the variation in teachers' perceived TPCEK scores was associated with differences in highest educational attainment. Teachers with doctoral units or a doctoral degree obtained the highest mean of 4.51, while those holding a bachelor's degree recorded the lowest mean of 4.13. These results suggest that teachers with higher educational qualifications tended to report greater perceived knowledge in integrating technology, pedagogy, content, and ethical principles. This finding relates to studies emphasizing that

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teachers' professional knowledge develops through advanced learning, reflective practice, and continuous professional development (Koehler et al., 2014; Chai et al., 2020). Similarly, professional preparation and opportunities for continued learning have been recognized as important in strengthening teachers' technological competence and responsible use of emerging technologies (Celik, 2023; Paidicán & Herrera, 2024). The findings point to the value of graduate education and sustained professional learning in developing teachers' perceived TPCEK, although the results do not establish that higher educational attainment directly causes greater competence.

Table 11.1. Post Hoc Analysis of Teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) When Grouped According to Highest Educational Attainment

Variables	Highest Educational Attainment (I)	Highest Educational Attainment (J)	Mean Difference (I–J)	p-value
1. TPCEK	Bachelor's Degree	With Master's Units	−.140	.218
		Master's Degree	−.300*	.012
		With Doctoral Units / Doctoral Degree	−.440*	.008
	With Master's Units	Bachelor's Degree	.140	.218
		Master's Degree	−.160	.184
		With Doctoral Units / Doctoral Degree	−.300*	.041
	Master's Degree	Bachelor's Degree	.300*	.012
		With Master's Units	.160	.184
		With Doctoral Units / Doctoral Degree	−.140	.526
	With Doctoral Units / Doctoral Degree	Bachelor's Degree	.440*	.008
		With Master's Units	.300*	.041
		Master's Degree	.140	.526

Table 11.1 presents the post hoc analysis of teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to highest educational attainment. Significant differences were observed between teachers holding a bachelor's degree and those with a master's degree (mean difference = −.300, p = .012) or doctoral units/doctoral degree (mean difference = −.440, p = .008), as well as between teachers with master's units and those with doctoral units/doctoral degree (mean difference = −.300, p = .041). The remaining comparisons showed no significant differences. These results suggest that teachers with advanced educational qualifications tended to report higher perceived TPCEK scores, although the differences were not significant across all groups. This finding relates to research emphasizing that teachers' professional knowledge develops through sustained learning, reflective practice, and opportunities to integrate technology into instruction (Koehler et al., 2014; Chai et al., 2020). Studies also highlighted the importance of professional preparation and continuous learning in strengthening teachers' technological competence and ethical use of emerging educational technologies (Celik, 2023; Nazaretsky et al., 2022). The findings suggest that advanced education and professional learning opportunities may be associated with differences in teachers' perceived TPCEK.

Table 12. Significant difference in the teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) in terms of Teaching Experience

Variable	Teaching Experience	N	Mean	f-value	p-value	Effect Size (η^2)	Interpretation
1. TPCEK and Teaching Experience	5 years and below	32	4.45	3.48	.017	.052	Significant
	6–10 years	67	4.38				
	11–20 years	65	4.29				
	More than 20 years	30	4.16				
	Total	194	4.33				

Table 12 shows a significant difference in teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to teaching experience, as indicated by $F(3, 190) = 3.48$, $p = .017$, and an effect size (η^2) of .052, indicating a small effect. This suggests that approximately 5.2% of the variation in teachers' perceived TPCEK scores was associated with differences in teaching experience. Teachers with five years of teaching experience and below obtained the highest mean of 4.45, while those with more than 20 years of experience recorded the lowest mean of 4.16. These results suggest that teachers with fewer years of teaching experience tended to report higher perceived TPCEK scores than their more experienced counterparts. This finding relates to studies indicating that teachers' technological competence and readiness to integrate emerging technologies may vary according to their professional backgrounds and

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experiences (Saharuddin et al., 2025; Paidicán & Herrera, 2024). However, teaching experience alone does not necessarily determine technological competence, as professional learning, instructional practice, and exposure to technology also contribute to the development of teachers' knowledge (Koehler et al., 2014; Nazaretsky et al., 2022). The findings point to the importance of providing professional development opportunities that respond to teachers' varying experiences and support their continued development of perceived TPCEK.

Table 12.1. Post hoc analysis of teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK) in terms of Teaching Experience

Variables	Teaching Experience (I)	Teaching Experience (J)	Mean Difference (I–J)	p-value
1. TPCEK	5 years and below	6–10 years	.070	.821
		11–20 years	.160	.183
		More than 20 years	.290*	.012
	6–10 years	5 years and below	–.070	.821
		11–20 years	.090	.547
		More than 20 years	.220*	.038
	11–20 years	5 years and below	–.160	.183
		6–10 years	–.090	.547
		More than 20 years	.130	.316
	More than 20 years	5 years and below	–.290*	.012
		6–10 years	–.220*	.038
		11–20 years	–.130	.316

Table 12.1 presents the post hoc analysis of teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK) when grouped according to teaching experience. Significant differences were observed between teachers with five years of experience and below and those with more than 20 years (mean difference = .290, p = .012), as well as between those with 6–10 years of experience and those with more than 20 years (mean difference = .220, p = .038). The remaining comparisons showed no significant differences. These results suggest that teachers with fewer years of teaching experience tended to report higher perceived TPCEK scores than those who had been teaching for more than two decades. This finding relates to studies indicating that teachers' technological competence and readiness to integrate emerging technologies may differ according to their professional experience and exposure to digital learning environments (Saharuddin et al., 2025; Paidicán & Herrera, 2024). Professional development and opportunities to engage with educational technologies have also been identified as important in strengthening teachers' knowledge and confidence (Nazaretsky et al., 2022; Koehler et al., 2014). The findings suggest the value of providing continuing professional learning opportunities that address the needs of teachers across different levels of teaching experience.

Research Question 3: Is there a significant interrelationship among the dimensions of Technological Pedagogical Content Ethical Knowledge (TPCEK)?

Table 13. Significant interrelationship among the dimensions of Technological Pedagogical Content Ethical Knowledge (TPCEK)

Dimensions	EK	PEK	CEK	TEK	TPEK	TCEK	PCEK	TPCEK
1. EK	1.000							
2. PEK	.682**	1.000						
3. CEK	.594**	.638**	1.000					
4. TEK	.621**	.577**	.548**	1.000				
5. TPEK	.653**	.784**	.612**	.731**	1.000			
6. TCEK	.608**	.635**	.762**	.746**	.718**	1.000		
7. PCEK	.697**	.795**	.773**	.586**	.751**	.729**	1.000	
8. TPCEK	.674**	.748**	.702**	.735**	.861**	.837**	.819**	1.000

Table 13 shows significant positive relationships among the eight dimensions of teachers' perceived Technological Pedagogical Content Ethical Knowledge (TPCEK), with correlation coefficients ranging from .548 to .861, all significant at the .01 level. The strongest relationship was found between Technological Pedagogical Ethical Knowledge (TPEK) and TPCEK (r = .861), followed by Technological Content Ethical Knowledge (TCEK) and TPCEK (r = .837), while the weakest relationship was observed between Content Ethical Knowledge (CEK) and Technological Ethical Knowledge (TEK) (r = .548). These results suggest that teachers who reported higher perceived knowledge in one dimension also tended to report higher perceived knowledge in other dimensions. This finding supports the view that technological, pedagogical, content, and ethical knowledge are interconnected rather than independent areas of knowledge (Deng & Zhang, 2023; Mishra & Koehler, 2006). Related studies also emphasized that effective technology integration requires

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teachers to combine professional knowledge with ethical judgment and responsible instructional practices (Celik, 2023; Paidicán & Herrera, 2024). The findings suggest that professional development should address these knowledge dimensions together rather than treating them as separate areas. However, these relationships are based on self-reported responses and do not establish actual teaching competence or causal relationships among the dimensions.

Ethical Considerations

This study adhered to ethical standards in educational research to protect the rights, privacy, and welfare of the respondents. Research ethics clearance was obtained from the Research Ethics Oversight Committee (REOC) of Western Mindanao State University under Ethics Clearance Code WMSU REO CODE 2026-GS-0752. Permission was also secured from the Schools Division Office of Zamboanga City and the participating school heads before data collection. Informed consent was obtained, and participation was voluntary, with the right to withdraw without consequences. Respondents' identities were protected through coding, and all data were treated confidentially in accordance with the Data Privacy Act of 2012 (Republic Act No. 10173). Research records were securely stored with access limited to authorized personnel and retained and disposed of according to the approved ethics protocol. Participation did not affect respondents' professional standing or performance evaluations.

Conclusion

The study concluded that public elementary school teachers in Baliwasan District reported a very high level of perceived Technological Pedagogical Content Ethical Knowledge (TPCEK), reflecting their perceived understanding of ethical principles in integrating technology, pedagogy, and subject content into teaching. Among the eight dimensions, Ethical Knowledge obtained the highest mean, while Content Ethical Knowledge recorded the lowest, suggesxting the need to further strengthen teachers' understanding of ethical considerations within specific subject areas. Significant differences in perceived TPCEK were found according to age, highest educational attainment, and teaching experience, although post-hoc comparisons revealed that these differences were limited to specific groups. Younger teachers, those with higher educational qualifications, and those with fewer years of teaching experience generally reported higher perceived TPCEK scores. Furthermore, all eight dimensions showed significant positive correlations, suggesting that teachers who perceived themselves as more knowledgeable in one dimension also tended to report higher perceived knowledge in other dimensions. These findings emphasize the importance of continuous professional development that integrates technological, pedagogical, content, and ethical knowledge while addressing teachers' varying professional learning needs. However, the findings are limited to public elementary school teachers in Baliwasan District and were obtained through a cross-sectional, self-report design without direct observation of classroom practices. Therefore, the results reflect teachers' perceived knowledge rather than demonstrated teaching competence and do not establish causal relationships. While the findings provide useful insights into teachers' professional learning needs, they should not be generalized beyond the study population without further evidence. Strengthening these areas through appropriate professional development may support teachers in making informed decisions and promoting responsible and ethical technology integration in classroom instruction.

Recommendations

Based on the findings, the study recommended that Department of Education Officials strengthen policies and professional development programs that promote the ethical integration of technology in teaching, particularly in developing teachers' Technological Pedagogical Content Ethical Knowledge (TPCEK). The Schools Division Office, through its training and development personnel, may organize annual professional development activities focusing on ethical decision-making, responsible technology use, and subject-specific ethical considerations. School Heads were encouraged to assess teachers' professional learning needs at the beginning of each school year and provide appropriate training, mentoring, and collaborative learning opportunities through regular Learning Action Cell (LAC) sessions. Although teachers with more than 20 years of teaching experience reported comparatively lower TPCEK scores than certain groups with fewer years of experience, the small effect size suggests that support should be based on individual learning needs rather than teaching experience alone. Teachers were advised to continuously improve their technological, pedagogical, content, and ethical knowledge through professional development, reflective teaching practices, and responsible use of digital resources. Particular attention should be given to strengthening Content Ethical Knowledge, which obtained the lowest mean among the eight dimensions. School Heads and LAC coordinators may monitor the implementation of these activities through training evaluations, teacher feedback, and periodic assessments of professional learning needs. Furthermore, future researchers were encouraged to examine other factors associated with teachers' TPCEK and explore how

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their perceived knowledge translates into actual classroom practices through classroom observations or longitudinal studies. These recommendations aim to support teachers' continuous professional growth and promote responsible, effective, and ethical technology integration in public elementary education.

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