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**MAPPING AI LITERACY AMONG PRIMARY SCHOOL TEACHERS IN PUNJAB,
PAKISTAN: A UNESCO AI COMPETENCY FRAMEWORK-BASED
MULTIDIMENSIONAL ASSESSMENT**

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KEYWORDS	ABSTRACT
Artificial intelligence, AI literacy, primary school teachers, UNESCO AI-CFT, teacher competency, AI in education, Pakistan, Punjab, teacher professional development.	The use of Artificial Intelligence (AI) in education is becoming a growing trend and is making new demands on the skills of teachers. Artificial intelligence (AI) is having a growing influence on the education sector and is posing new challenges to the skills of teachers. The UNESCO AI Competency Framework for Teachers (AI-CFT) was used to check the level of AI literacy among primary school teachers in Punjab, Pakistan. The study was conducted in the form of a quantitative, cross sectional and descriptive comparative survey in 9 districts of 3 divisions of Punjab. An AI-literacy test comprising 25 objective items was created in five dimensions of the UNESCO AI-CFT. Six experts reviewed the instrument and 40 teachers had it piloted. A total of 517 questionnaires were received and 477 questionnaires were analyzed using descriptive and inferential statistics, such as t-test, ANOVA. The study aims to present a multidimensional assessment of teachers' AI literacy and design competency patterns for the five dimensions of AI-CFT to provide an empirical basis for context-specific AI professional development and teacher training in Punjab.
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Introduction

The competency of teachers in AI is emerging as a crucial precondition for meaningful and responsible use within schooling contexts, to support assessment, create content, facilitate adaptive learning, provide feedback, and support productivity (Dringó-Horváth et al., 2025; Dou & Zhao, 2025; Zhang & Zhang, 2024; Wang et al., 2023). In the research literature, AI literacy is no longer

just a technical ability but a complex ability that consists of an understanding of the operation of AI, the correct use of tools, critical analysis of the outcomes and implications of AI, and consideration of ethical and societal issues (Zhao et al., 2022; Ng et al., 2021; Biagini, 2025). Often, AI literacy has been described as a collection of skills and abilities that allow individuals to critically assess AI technologies, effectively communicate and collaborate with AI, and use AI as a tool in various contexts (Sperling et al., 2024; Chiu et al., 2024; Dringó-Horváth et al., 2025; Dou & Zhao, 2025).

In the field of education, the expanded definition has led to an evolution away from a generic definition of digital competence to a more nuanced one of teacher-specific AI competence models. Recent studies have drawn a distinction between literacy and competency, viewing literacy as the knowledge base and shared language for understanding AI, while competency is the application of that knowledge in professional tasks including lesson planning, assessment, classroom decision-making and reflective improvement that are context-bound (Chiu et al., 2024; Zhou et al., 2025; Hsu, 2026). This distinction is particularly relevant to school education as teachers are expected to utilize AI both personally and educate students to do so safely, critically and equitably (Bai, 2025; Dou & Zhao, 2025; Hsu, 2026).

One of the most extensive frameworks for responding to this need is contained in the UNESCO AI Competency Framework for Teachers. The framework comprises five components of teacher AI competence (human-centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional development) and three levels of progression: Acquire, Deepen, and Create (Zainuddin et al., 2025; Bai, 2025; Dringó-Horváth et al., 2025; Hsu, 2026). The framework is clearly international, and can be used directly as a reference for national frameworks, teacher training and assessment design, as well as to focus on human agency and responsibility in using the framework, rather than just on instrumentally adopting the framework (Bai, 2025; Dringó-Horváth et al., 2025; Sufyan & Kurniawan, 2026; Hsu, 2026). Given that it combines both technical, pedagogical, ethical, and developmental aspects in a staged approach, it can be particularly applied at multi-dimensional mapping of teacher preparedness, especially in rapidly advancing contexts where the adoption of AI is outpacing formal capacity building (Dou & Zhao, 2025; Hossain et al., 2026).

In the context of Pakistan with unequal infrastructure, inconsistent institutional support, and the existing urban-rural divide, this is an important concern regarding digital transformation in Education. Research on digital inclusion in Pakistan reveals that digital connectivity, ownership of digital devices and access to ICT usage remains socio-geographically, gender, income and education segregated (Jamil, 2021; Waqar et al., 2024; Sami, 2025; Iftikhar et al., 2023). At the school level, research highlights existing challenges such as the lack of adequate infrastructure, access to technology, teacher preparation, privacy concerns, and differences in digital literacy across schools within the province of Punjab (Ghani et al., 2024; Safdar et al., 2026). AI research specific to Pakistan also indicates that teachers appreciate the potential of AI tools for boosting engagement and efficiency, but express a lack of training, financial constraints, ethical concerns, and a desire for professional development (Haq, 2025; Farooq, 2025).

The divide widens in primary school. Teachers' interest in using AI has been reported in international primary schools, however, lack of content knowledge, pedagogical confidence, and ethical preparedness have been reported to hinder meaningful use of AI in primary schools (Kim & Kwon, 2023; Mazi & Yildirim, 2025; Boiko, 2025). Additionally, previous studies have shown that practical skills tend to be less developed than conceptual knowledge and ethical acceptance, highlighting the common theory-practice divide in teacher AI literacy (Al-Abdullatif, 2025; Wu & Annamalai, 2026; Hu & Wang, 2026). This is particularly relevant for Punjab, where the exposure of teachers to AI tools is increasing, and their policy aspirations are catching up. This is particularly important for Punjab where the exposure of teachers to AI tools is on the rise and their policy aspirations are also rising (Jamil et al., 2025; Rasheed, 2026).

In this context, the current study fills the empirical and policy void by providing a picture of AI literacy of primary school teachers in Punjab, Pakistan, using the UNESCO AI Competency Framework. Overall preparedness can be illustrated from a UNESCO-based multidimensional assessment, along with strengths and weaknesses on each of the domains regarding human-centered values, ethics, technical foundations, pedagogy and professional learning (Nam & Choi, 2026; Qi et al., 2026; Dou, 2026). This evidence is crucial for creating context-specific professional development that addresses rural-urban disparities, matches institutional resources to teachers' needs, and validates a focus on education instead of technology when implementing AI (Xiang et al., 2026; Wu & Annamalai, 2026; Tahir et al., 2025; Afzal et al., 2026).

Literature Review

In the field of education, AI literacy has become an important construct, but its meaning has been the subject of a few overlapping discourses. The first influential research focused on four recurring areas of focus related to AI literacy: Knowledge and understanding of AI, using and applying AI, evaluating and creating an AI, and AI ethics (Ng et al., 2021; Velander et al., 2023; Arkorfol et al., 2026). It is widely implemented in teacher studies in China, Ghana, Saudi Arabia, and Israel, showing high convergence in the cognitive, practical, evaluative and ethical dimensions of the construct (Zhao et al., 2022; Arkorfol et al., 2026; Al-Abdullatif, 2025; Deshen et al., 2026). However, the same literature also highlights the complexity of AI literacy, which is not only overlapping with digital literacy, but also encompasses additional factors, such as critical evaluation, ethical reasoning, or AI-specific judgment, which call for differentiated professional development (Tenberga & Daniela, 2024; Dringó-Horváth et al., 2025).

More contemporary models are based on this foundation but add confidence, self-reflection, collaboration, contextualisation, autonomy and human-centredness. Chiu and colleagues (2024; Zhou et al., 2025) suggest that while literacy is about knowing, competency is about the use of knowledge, which involves confidence and self-reflective attitudes. The ED-AI Lit framework also outlines six dimensions: knowledge, evaluation, collaboration, contextualization, autonomy, and ethics, emphasizing actual human-AI interaction and not just the operation of the tool (Allen & Kendeou, 2023). In addition to knowledge and skills, teacher AI literacy should also encompass the

contextual aspects, ongoing professional development, and psychological or affective aspects of AI applications (Feng & Carolus, 2026; Pei et al., 2026). The developments indicate the possibility of implementing the use of wider competency models, particularly in the work of teachers, who have to make certain professional judgments under the conditions of the real classroom (Pardillo et al., 2026; Baizhanov et al., 2026; Aulia et al., 2026).

The second major strand of the literature is related to measurement. A consistent finding is that teacher AI literacy is not necessarily equivalent to general digital competence, and that it should be measured using specific and psychometrically valid tools (Tenberga & Daniela, 2024; Xiang et al., 2026; Delcker et al., 2024). The structures of the instruments are varying. Four-dimensional models are still frequent, particularly in cases where researchers try to evaluate knowledge, application, evaluation and ethics (Arkorful et al., 2026; Zhang et al., 2026). Other instruments extended the construct to five, six or more dimensions, e.g., AI knowledge, use, assessment etc. (Pan & Wang, 2025; Chiu et al., 2024; Younis, 2025). Measurement work based on UNESCO is particularly significant because it helps to convert a policy into a structured matrix of assessments and validated scales across various domains and stages of progress (Dou & Zhao, 2025; Nam & Choi, 2026; Dou, 2026).

Table 1: *Selected Measurement Models*

Framework / Instrument	Core Dimensions	Teacher Relevance	Citation
Ng et al. four-dimensional model	Knowledge, evaluation/creation, ethics	application, Widely used baseline conceptualization	(Ng et al., 2021)
UNESCO AI-CFT	Human-centered mindset, ethics, foundations/applications, professional development	Global teacher-specific competency framework	(Zainuddin et al., 2025; Hsu, 2026)
TAICS	AI knowledge, pedagogy, ethics, human-centered professional engagement	Assessment, Adds assessment as a distinct teacher competency	(Chiu et al., 2024)
TAILS / ED-AI-based scale	Knowledge, evaluation, contextualization, autonomy, ethics	collaboration, Highlights context and autonomy in teacher education	(Nabhan & Habók, 2026)
UNESCO-based Korean tool	15 components in 5 domains	Large-sample operationalization of AI-CFT	(Nam & Choi, 2026)

The results of the empirical studies conducted across countries reveal patterns which are directly applicable to Punjab. While many teachers are positive about AI, they are not well informed about AI basics and the confidence in its pedagogical application is still low (Du et al., 2024; Yue et al.,

2024; Kayıran et al., 2026; Mustafa et al., 2024). As for elementary and primary schools, teachers have less confidence in AI content knowledge and its use in the classroom, despite their desire to adopt AI (Kim & Kwon, 2023; Boiko, 2025; Fuchs & Lenzgeiger, 2026). Several studies show that in terms of ethical awareness, teachers' scores are higher than their scores in terms of using AI in practice, indicating that teachers are more inclined to endorse ethical AI use than building strong application competence (Al-Abdullatif, 2025; Wu & Annamalai, 2026; Oktaviani et al., 2026; Hu & Wang, 2026).

Additionally, there are elements that influence the development of AI literacy. There are also elements that influence the development of AI literacy that are identified in the literature. The results are that, self-efficacy, perceived social good, attitudes, and confidence are consistently related to learning intention or readiness, and supportive school environments and professional communities are associated with competence development (Du et al., 2024; Yang et al., 2024; Wu & Annamalai, 2026; Fundi et al., 2024). Access to training, encouragement from leaders, school culture, and opportunities to experiment in the real world are consistently identified as enabling factors, alongside individual motivation (Alexandron et al., 2026; Kayıran et al., 2026; Ayesha et al., 2026; Lademann et al., 2025). Meanwhile, there are some differences in AI literacy profiles linked to age, experience, school location, and background in the subject (Pan & Wang, 2025; Xiang et al., 2026; Wu & Annamalai, 2026; Younis, 2025; Wang et al., 2023), but these are not always consistent across studies or contexts. The present study draws particularly on the literature in the Global South and how it illustrates the key role infrastructure, language, school type, and policy context play in AI literacy. In India, teachers' AI understanding tended to be superficial in nature, lacking practical exposure in rural and government schools, and having a greater ethical dilemma due to inadequate training and governance (Kundu et al., 2025). Studies across the nations indicate that having access to AI does not automatically lead to deep knowledge and understanding of AI, and that the type of support, the quality of that support, and how students engage with the AI can make the difference (Aguilar et al., 2026). Comparative studies also suggest that cultural and educational systems influence the emergence of AI literacy, thus highlighting the need to discard any assumption of a one-size-fits-all approach (Aksoy et al., 2026).

The need for a context-specific study is even stronger in the case of Pakistan. Studies in Punjab and Pakistan indicate that AI integration is gaining traction, albeit with uneven levels, lack of organization, infrastructure, institutional silence, and inadequate formal training (Boota et al. 2026; Rasheed 2026; Afzal et al. 2026). The use of ChatGPT in rural and urban Pakistani primary schools are significantly different across internet, electricity and device access, along with a lack of training and strict curriculum policies (Ali et al., 2026). In Punjab specifically, teachers report moderate ICT competence, and weaker competence with AI in particular, with areas of weakness including personalization, the use of AI in the classroom, and ethical implementation; and high demand for training and enhanced infrastructure (Safdar et al., 2026). However, in the context of higher education and higher education institutions, and even in South Punjab, Pakistani studies all agree that the same factors that enable students to be ready for and trust AI—digital competence, self-

efficacy, perceived usefulness, and institutional support—are likely to matter in primary schools as well (Tahir et al., 2025; Rafiq & Chaudhry, 2026; Farooq, 2025).

Research Gap and Study Positioning

There are 3 gaps in the literature. First, teacher AI literacy research is still younger and less dense in comparison to student AI literacy research studies, and the sample of primary school teachers is still limited compared to secondary and higher education teachers (Yue et al., 2024; Tan & Tang, 2025; Pardillo et al., 2026). Second, most of the studies are based on general or four-dimensional frameworks, and a few studies have operationalized the broader UNESCO AI-CFT framework in the school teacher population (Ng et al., 2023; Chiu et al., 2024; Qi et al., 2026; Nam & Choi, 2026). Third, there is a strong indication of policy ambition, infrastructure imbalances, and training requirement, despite weak evidence of the multidimensional AI literacy of the school teachers in Pakistan, particularly the Punjab province (Boota et al., 2026; Rasheed, 2026; Ali et al., 2026; Afzal et al., 2026).

The UNESCO AI Competency Framework-based multidimensional teacher assessment for primary school teachers of Punjab directly tackles these gaps, and provides baseline information on a strategic population that has not been studied extensively. It is also aligned with a framework explicitly developed for phased learning and teacher development, ethical responsibility, pedagogical integration, and human-centered use of AI (Bai, 2025; Dou & Zhao, 2025; Hsu, 2026). One key change in the literature reflects the transition from the conception of AI literacy as mere familiarity of the basic tools to the recognition of it as a complex professional skill encompassing knowledge, pedagogy, ethics, agency, and lifelong learning (Chiu et al., 2024; Dilek et al., 2025; Pei et al., 2026). The most salient issue to be explored is how these dimensions converge, conflict and are put into practice in under-resourced primary school systems like Punjab in which the infrastructure, policy and professional learning environment vary greatly. The emerging literature indicates three important gaps.

First, teacher AI literacy is becoming a topic of increased research, but its measurement is fragmented. Evidence in the systematics literature suggests that most current assessments are self-report based and do not have evidence of actual knowledge.

Second, there are substantial variations in the dimensions captured by the current tools. Causing it to be hard to compare results between studies and highlighting the merit of theory based assessment frameworks.

Third, limited empirical evidence has been found on the AI literacy of primary school teachers in Pakistan with cross-country geographical settings varying from one to five across the five dimensions of UNESCO's AI-CFT (AI for primary education).

The present study fills these gaps by applying 25 item objective assessment that is based on UNESCO's AI-CFT and analysing primary school teachers from nine districts of three divisions in Punjab.

Problem Statement

With the rise of AI in education, teachers should have the necessary knowledge to use AI effectively and responsibly. Yet, the actual level of literacy of Primary School Teachers (PSTs) in the context of AI in Pakistan is yet to be documented properly. Many existing studies have been based on self-report measures of knowledge, confidence, and preparedness, rather than on teachers' knowledge or ability to use AI appropriately. Some existing studies are based on teachers' self-report measures of knowledge, confidence, and preparedness, but this is not a reflection of their actual knowledge or ability to use AI appropriately.

Additionally, the overall AI literacy scores can hide differences in the four competency areas: AI foundations, ethics, pedagogy, human-centered thinking, and the use of AI professionally. Thus, a multi-dimensional and objective evaluation is required. This study bridges this gap by conducting a study with primary school teachers on AI literacy assessment using the 25 items that have been formulated on the basis of the five AI-CFT dimensions in nine districts of Punjab.

Research Objectives

The goals of the study were:

1. To assess the overall level of AI literacy in primary school teachers of Punjab, Pakistan.
2. To measure the primary school teachers' AI literacy in terms of the five dimensions of the UNESCO AI Competency Framework for Teachers.
3. To locate the relatively stronger and weaker aspects of teachers' AI literacies in primary schools.
4. To explore gender and age, experience, qualification and rural/urban differences in teachers' AI literacy.
5. Create a multidimensional AI literacy profile of primary school teachers using the five dimensions of the UNESCO AI-CFT.

Research Questions

1. How much does teachers in primary schools in Punjab, Pakistan know about AI?

2. How well is the primary school teachers' AI literacy in all the five dimensions of the UNESCO AI Competency Framework for Teachers?
3. In what sense is teachers' AI literacy stronger or weaker in the relatively stronger and weaker dimensions of UNESCO AI-CFT?
4. Is there a statistically significant difference in teachers' AI literacy based on gender, age, teaching experience, qualification, or teacher's rural/urban location?
5. What is the profile of AI literacy of primary school teachers in the five UNESCO AI-CFT dimensions?

Research Hypotheses

The following null hypotheses were considered and tested at the .05 level of significance for inferential parts of the study.

H01: Male and female primary school teachers do not significantly differ with regards to overall scores on AI literacy.

H02: The overall AI literacy scores of primary school teachers from rural and urban schools are not significantly different.

H03: No significant difference exists between AI literacy of different age groups of primary school teachers.

H04: AI literacy is not significantly different between different levels of primary school teachers' teaching experience.

The level of teachers' AI literacy in primary schools does not differ statistically in relation to their qualification level.

Conceptual Framework

The conceptual foundation of the study is UNESCO's AI Competency Framework for Teachers. Five dimensions are identified in the framework:

- A. Human-Centred Mindset
- B. Ethics of AI
- C. AI Fundamentals and Applications.
- D. AI Pedagogy

E. AI for Professional Learning

These dimensions serve as the foundation for the operationalisation of AI-literacy for the purpose of the current study. UNESCO considers these to be 15 competencies spread across the five dimensions and placed in the three progression levels: Acquire, Deepen and Create. AI literacy is defined as a multidimensional rather than a monodimensional phenomenon.

Conceptual model

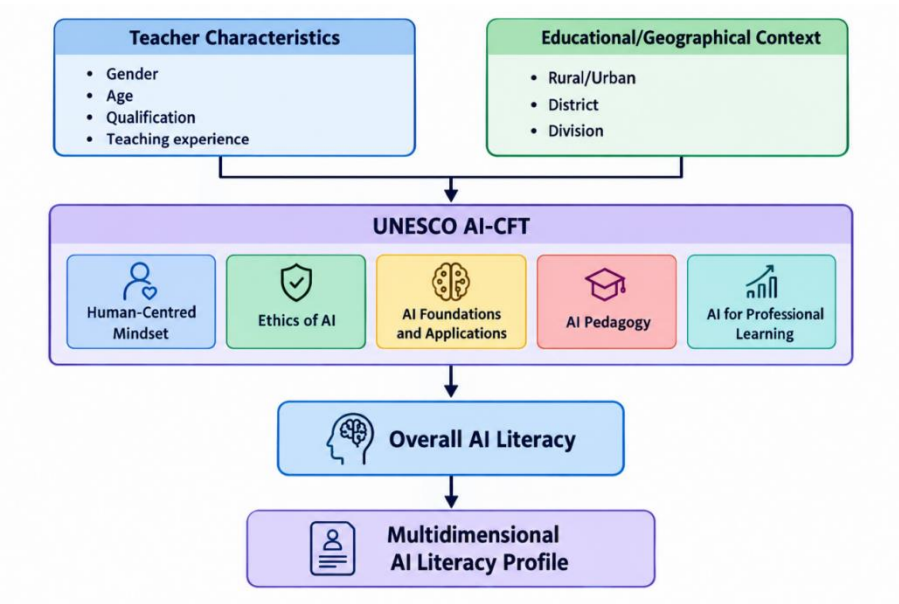


Fig 1: Conceptual framework

Methodology

Research Design

The study used a quantitative, cross-sectional and descriptive-comparative survey research design to evaluate the AI literacy of teachers and explore the variations between selected demographic and geographical groups.

Students and the number of samples.

Study Population and Sampl size

Table 2:

Division	Selected districts
Lahore Division	Lahore, Kasur, Sheikhupura
Rawalpindi Division	Rawalpindi, Jhelum, Chakwal
Multan Division	Multan, Khanewal, Vehari
Total	9 districts

The respondents included government primary school teachers of Punjab, Pakistan. Three divisions: Lahore, Rawalpindi and Multan had been covered under the multistage geographical sampling process and nine districts (Lahore, Kasur, Sheikhupura, Rawalpindi, Jhelum, Chakwal, Multan, Khanewal and Vehari). Strata were taken into account for rural/urban and male/female. The paper-based questionnaire was sent to all education authorities electronically (DEOs and AEOs) and was distributed voluntarily.

Table 3:

Data collection stage	Number
Target sample	500
Main survey responses	517
Pilot responses excluded	40
Final usable sample	477

The target was 500 teachers. 517 responses were received, 40 of which were pilot responses, leaving 477 valid responses for final analysis.

Instrument Development

Structured questionnaire was prepared for data collection. There were two sections of the instrument. The first section collected information regarding participants' gender, age, academic qualification, teaching experience, rural/urban location, district; and division. The following section provides a brief summary of Assessment B: AI Literacy Assessment (Based on the UNESCO-AI-CFT). The second part was made up of 25 multiple-choice objective questions based on the UNESCO's AI-CFT. The 5 dimensions were represented by 5 questions.

Table 4:

UNESCO AI-CFT dimension	Items
Human-Centred Mindset	5
Ethics of AI	5
AI Foundations and Applications	5

UNESCO AI-CFT dimension	Items
AI Pedagogy	5
AI for Professional Learning	5
Total	25

One point was awarded for every correct answer and zero points were awarded for every wrong answer. Overall, the AI literacy score was in the range of 0 to 25. The scores for the domains varied from 0 to 5. A higher score indicated a higher level of AI literacy demonstrated. The instrument has been created by correlating the assessment items on UNESCO's five AI-CFT dimensions.

Table 5:

Dimension	Items	Assessment focus
Human-Centred Mindset	5	Human agency and the human role in AI-supported education
Ethics of AI	5	Privacy, fairness, bias, responsibility and ethical AI use
AI Foundations and Applications	5	Fundamental AI concepts, data, models, algorithms and applications
AI Pedagogy	5	Educational and instructional applications of AI
AI for Professional Learning	5	Professional use of AI and AI-supported teacher development
Total	25	Multidimensional AI literacy

These are the five dimensions and 15 competencies identified by the UNESCO framework and are outlined in terms of being acquired at the Acquire, Deepen and Create levels.

Validity and Reliability

Six experts in the fields of education, teacher education, educational technology and AI evaluated the instrument for relevance, clarity, appropriateness, alignment with the UNESCO AI-CFT, and suitability for primary teachers. Feedback was used to make the needed revisions. Then, a pilot study was done involving 40 primary school teachers to evaluate clarity, administration, functionality, and initial reliability. The pilot responses were not used in the final data and the instrument exhibited good preliminary reliability (Cronbach's $\alpha = .794$). If the original data for dichotomous AI-literacy items are available, then the KR-20 can also be reported.

Data Collection Procedure

The last questionnaire was made on a Google Forms on-line questionnaire. The survey link was shared with the primary school teachers via the relevant education authorities in the districts that

were selected following administrative cooperation. The participants were told about the research and that they participated in it voluntarily. A total of 517 responses were received in the main data collection. 40 pilot responses were not included in the final data set, leaving 477 data points.

Ethical Considerations

The study abided by the basic ethical principles of educational research. The survey was anonymous and the participants were briefed on the objectives of the study prior to answering the questionnaire. The data were anonymized and only used for research purposes. The results were reported and analysed in aggregate format, not allowing the identification of individual participants from the reported results.

Data Analysis

There were 517 responses, and 477 complete cases for analysis. The 5 dimensions of AI-literacy were assessed in the 25-item objective test, and included the following: human-centred mindset, AI foundations, AI pedagogy, AI ethics, and professional learning. The scores ranged from 3–25 with scores higher than 25 representing higher AI literacy. This instrument had a satisfactory internal consistency (Cronbach's $\alpha = .876$). Study-specific bands were used to interpret AI literacy as low (0–14) moderate (15–19), and high (20–25). These bands are not official UNESCO levels of proficiency but are study-specific.

Results

Participant Profile

The final sample comprised of 477 primary school teachers of Punjab, Pakistan. Teachers from nine districts were included in the sample, which comprised of Chakwal, Jhelum, Kasur, Khanewal, Lahore, Multan, Rawalpindi, Sheikhupura and Vehari.

Table 6: Demographic Characteristics of the Participants

Variable	Category	n	%
Gender	Female	344	72.1
	Male	133	27.9
School location	Rural	361	75.7
	Urban	116	24.3
Age	25–35 years	175	36.7
	35–45 years	204	42.8
	45–55 years	77	16.1

Variable	Category	n	%
Teaching experience	55 years and above	21	4.4
	5–10 years	220	46.1
	10–15 years	134	28.1
	15–25 years	84	17.6
	More than 25 years	39	8.2
Qualification	BA/BSc/B.Ed	55	11.5
	MA/MSc/M.Ed	325	68.1
	MPhil and professional qualification	94	19.7
	PhD and professional qualification	3	0.6

The sample was predominantly female and rural. Most participants were between 25 and 45 years of age, had 5–15 years of teaching experience, and held a master’s-level qualification.

Reliability of the AI-Literacy Instrument

Table 7: Reliability Statistics for the AI-Literacy Instrument

Measure	Value
Number of items	25
Number of valid responses	477
Cronbach’s alpha	.876
Interpretation	Good internal consistency

The Cronbach’s alpha coefficient of **.876** indicates that the items demonstrated good internal consistency and were sufficiently related for the purpose of measuring teachers’ overall AI literacy.

RQ1: What is the overall level of AI literacy among primary school teachers in Punjab, Pakistan?

The overall AI-literacy score had a possible range of 0–25. The observed mean was 18.39 with a standard deviation of 5.37. This represents approximately 73.54% of the maximum possible score.

Table 8: Overall AI-Literacy Scores

Statistic	Value
Valid N	477
Mean	18.39
Standard deviation	5.37
Median	19.00
Minimum	3
Maximum	25

Statistic	Value
Percentage of maximum score	73.54%
Interpretation	Moderate overall level

Using the study-specific objective-score categories, 224 teachers, or 47.0%, achieved high AI-literacy scores, while 145 teachers, or 30.4%, fell within the moderate category. A further 108 teachers, or 22.6%, were classified in the low category.

Table 9. *Distribution of Teachers by Overall AI-Literacy Level*

AI-literacy level	Score range	n	%
Low	0–14	108	22.6
Moderate	15–19	145	30.4
High	20–25	224	47.0
Total		477	100.0

Although almost half of the teachers achieved high scores, the overall mean remained below the high-performance band. This indicates that teachers generally possessed a developing or moderately strong foundation in AI literacy, but a substantial minority required systematic professional development.

Distribution of Overall AI-Literacy Scores

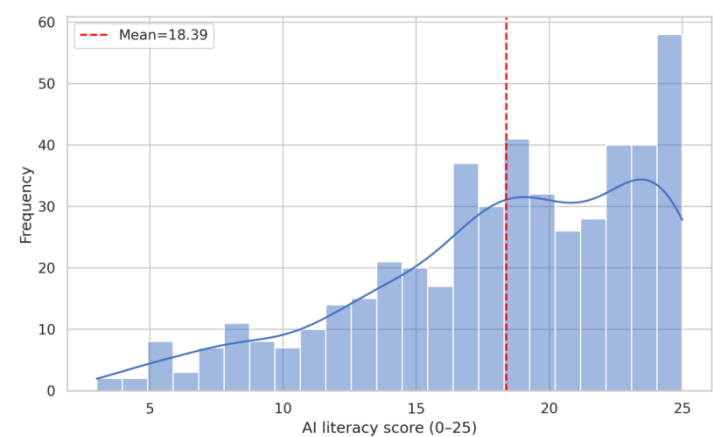


Fig 2: *Distribution of Overall AI-Literacy Scores*

Histogram of total AI-literacy scores with a vertical line indicating the mean score of 18.39. The distribution of scores indicates considerable variation among teachers. The minimum score of 3 and

maximum score of 25 demonstrate that teachers differed substantially in their understanding of AI concepts, applications, ethics, and professional learning.

RQ2: What is the level of primary school teachers' AI literacy across the five dimensions of the UNESCO AI-CFT?

Each dimension consisted of five objective items. Therefore, the possible score for each dimension ranged from 0 to 5.

Table 10: AI Literacy Across the Five Dimensions

Rank	Dimension	Mean	SD	Percentage correct
1	AI pedagogy	4.01	1.27	80.17
2	Human-centred mindset	3.86	1.31	77.23
3	Professional learning	3.77	1.35	75.47
4	AI foundations	3.50	1.33	69.94
5	Ethics of AI	3.25	1.45	64.91

The highest mean score was obtained for AI pedagogy ($M = 4.01$, $SD = 1.27$), followed by human-centred mindset ($M = 3.86$, $SD = 1.31$). This suggests that teachers were relatively more successful in identifying appropriate classroom applications of AI and understanding the teacher's role in AI-supported learning. The lowest mean score was recorded for ethics of AI ($M = 3.25$, $SD = 1.45$). The comparatively larger standard deviation also indicates substantial variation between teachers in their understanding of bias, transparency, consent, privacy, responsible use, and ethical risks. AI foundations recorded a mean of 3.50, equivalent to approximately 69.94% correct responses. This indicates that teachers possessed a developing understanding of basic AI concepts, but their knowledge was less secure than their knowledge of classroom applications.

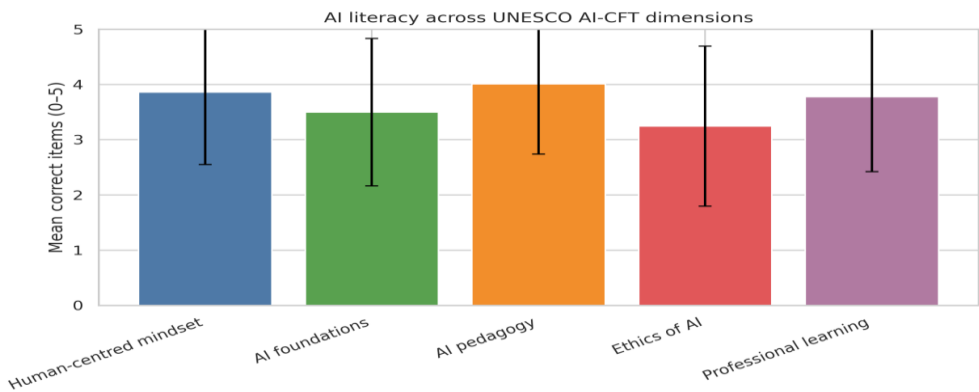


Fig 3: Mean Scores Across the Five AI-CFT Dimensions

Bar chart showing the mean scores for AI pedagogy, human-centred mindset, professional learning, AI foundations, and ethics of AI.

RQ3: Which UNESCO AI-CFT dimensions represent the relatively stronger and weaker areas of primary school teachers' AI literacy?

The dimension-level findings reveal a clear pattern of strengths and weaknesses.

Stronger and Weaker Areas

AI pedagogy was the strongest dimension, with teachers showing better understanding of AI-supported learning, assessment, chatbots, and critical evaluation of AI-generated content. **Human-centred mindset** was also relatively strong, particularly regarding teachers' professional judgment and the role of AI as a support rather than a replacement for teachers.

In contrast, **AI ethics** was the weakest area, particularly in relation to bias, transparency, consent, data protection, fairness, and responsible AI use. **AI foundations** was another weaker area, with some difficulty distinguishing AI, machine learning, deep learning, and conventional digital technologies.

Table 11: *Interpretive Summary of Stronger and Weaker Dimensions*

Dimension	Mean	Relative position	Interpretation
AI pedagogy	4.01	Strongest	Teachers showed comparatively strong awareness of classroom uses of AI.
Human-centred mindset	3.86	Strong	Teachers generally supported teacher judgment and human oversight.
Professional learning	3.77	Moderately strong	Teachers recognized the importance of continuous AI development.
AI foundations	3.50	Moderate	Basic conceptual knowledge was developing but uneven.
Ethics of AI	3.25	Weakest	Ethical, privacy, fairness, and bias-related knowledge requires priority attention.

The pattern suggests that teachers may be more familiar with the practical and instructional uses of AI than with the principles needed to govern AI responsibly. In other words, teachers may know how AI can be used in teaching more readily than how AI should be evaluated, monitored, and regulated.

RQ4: Are there statistically significant differences in teachers' AI literacy according to gender, age, teaching experience, qualification, and rural/urban location?

Independent-samples t tests were used for gender and school location. One-way analyses of variance were used for age, teaching experience, and qualification.

Table 12: AI-Literacy Scores by Gender

Gender	Female	Male
n	344	133
Mean	18.54	18.00
SD	5.51	5.00

The difference between female and male teachers was not statistically significant, $t(\text{approximately } 262.52) = 1.02, p = .310$. The effect size was negligible, Cohen's $d = 0.10$. Therefore, **H01 was retained**.

Table 13: AI-Literacy Scores by School Location

School location	n	Mean	SD
Rural	361	18.52	5.21
Urban	116	17.96	5.85

The difference between rural and urban teachers was not statistically significant, $t(\text{approximately } 177.42) = 0.93, p = .353$. The effect size was negligible, Cohen's $d = 0.11$. Therefore, **H02 was retained**.

Table 14: AI-Literacy Scores by Age Group

Age group	n	Mean	SD
25–35 years	175	18.17	5.56
35–45 years	204	18.51	4.96
45–55 years	77	18.60	5.72
55 years and above	21	18.29	6.50

The one-way ANOVA indicated no statistically significant differences in AI literacy across age groups, $F(3, 473) = 0.17, p = .915, \eta^2 = .001$. Therefore, **H03 was retained**.

Table 15: *AI-Literacy Scores by Teaching Experience*

Teaching experience	n	Mean	SD
5–10 years	220	18.37	5.36
10–15 years	134	18.31	5.18
15–25 years	84	18.54	5.35
More than 25 years	39	18.38	6.24

There was no statistically significant difference in AI literacy across experience groups, $F(3, 473) = 0.03, p = .993, \eta^2 < .001$. Therefore, **H04 was retained**.

Table 16: *AI-Literacy Scores by Qualification*

Qualification	n	Mean	SD
BA/BSc/B.Ed	55	17.75	6.22
MA/MSc/M.Ed	325	18.40	5.19
MPhil and professional qualification	94	18.73	5.55
PhD and professional qualification	3	17.33	3.06

The differences in AI literacy across qualification groups were not statistically significant, $F(3, 473) = 0.43, p = .731, \eta^2 = .003$. Therefore, **H05 was retained**.

Table 17: *Summary of Demographic and Contextual Hypothesis Tests*

Hypothesis	Comparison	Test statistic	p	Effect size	Decision
H01	Gender	$t = 1.02$	.310	$d = .10$	Retain H01
H02	Rural/urban location	$t = 0.93$	.353	$d = .11$	Retain H02
H03	Age groups	$F = 0.17$	.915	$\eta^2 = .001$	Retain H03
H04	Experience groups	$F = 0.03$	.993	$\eta^2 < .001$	Retain H04
H05	Qualification levels	$F = 0.43$	.731	$\eta^2 = .003$	Retain H05

Overall, the results indicate that teachers' AI literacy was relatively consistent across gender, school location, age, teaching experience, and qualification. None of the observed differences reached the .05 level of statistical significance.

Table 18: District-Level Analysis of Variance

Source	SS	df	MS	F	p	η^2
Between districts	438.0	8	54.75	1.91	.057	.032
Within districts	Approximately 13,400	468	Approximately 28.63			
Total	Approximately 13,838	476				

Mean AI-Literacy Scores by District

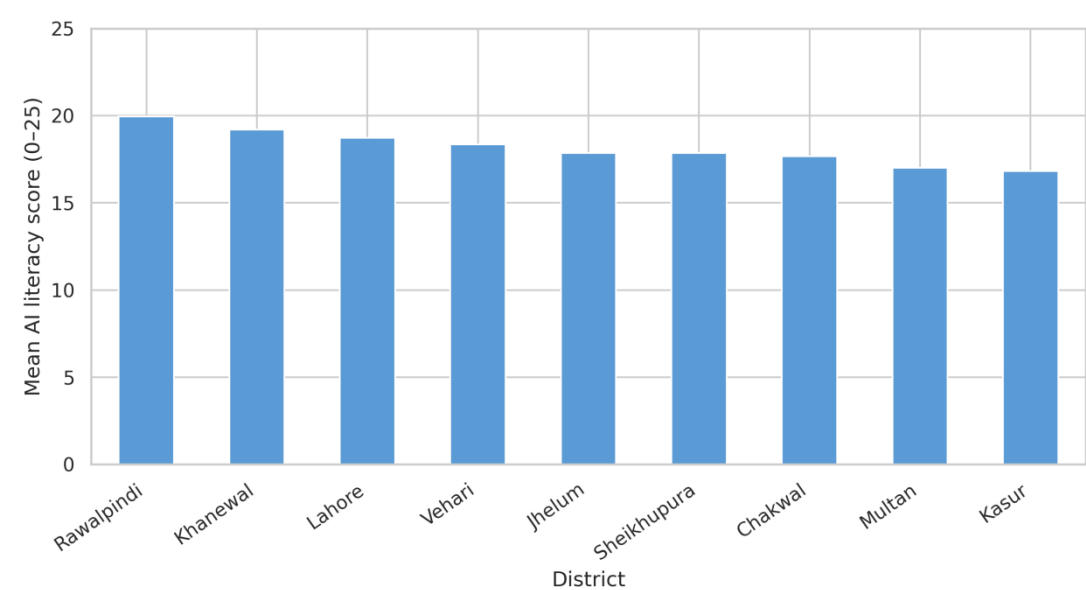


Fig 4: Mean AI-Literacy Scores by District

Bar chart showing district means with error bars representing standard deviations. The relatively higher score observed in Rawalpindi and the relatively lower score observed in Kasur should be interpreted descriptively rather than as evidence of statistically significant geographical inequality. The results suggest possible district-level variation, but the current sample does not provide sufficient evidence to conclude that teachers' AI literacy differs systematically by district.

RQ6: What multidimensional AI-literacy profile emerges among primary school teachers across the five UNESCO AI-CFT dimensions?

To address RQ6, a three-profile k-means cluster analysis was conducted using the five dimension scores. The profiles were interpreted according to their mean scores across the five dimensions.

Table 19: *Multidimensional AI-Literacy Profiles*

Profile	Interpretation	n	%
Profile 1	Low/limited AI literacy	78	16.4
Profile 2	Pedagogy-oriented moderate literacy	190	39.8
Profile 3	High/holistic AI literacy	209	43.8
Total		477	100.0

Table 20: *Mean Dimension Scores for the Three AI-Literacy Profiles*

Profile	Human-centred mindset	AI foundations	AI pedagogy	Ethics of AI	Professional learning
Profile 1: Low/limited	1.91	1.92	1.83	1.78	1.69
Profile 2: Pedagogy-oriented moderate	3.80	3.04	4.03	2.49	3.64
Profile 3: High/holistic	4.65	4.50	4.80	4.48	4.67

Proficient 1: Low/Limited AI Literacy

In the first profile, there were 78 teachers or 16.4% of the sample. On all 5 dimensions, these teachers performed at a lower level than sample average. They scored the lowest in the areas of professional learning, ethics of AI, and AI pedagogy. This profile describes teachers who might need some basic training to be able to confidently use AI in their classrooms. They will likely require basic computer skills, an understanding of the fundamentals of artificial intelligence, knowledge of responsible practices, hands-on experience and guidance, and access to suitable digital resources.

Profile 2: Pedagogy Oriented - Moderate Literacy

The second profile was composed of 190 teachers (39.8 percent of the sample). The knowledge regarding AI-pedagogical knowledge was relatively higher, 4.03, while knowledge regarding AI foundations and ethics was much lower as shown in Table 1. This is a very critical group for professional development. These teachers seem prepared to leverage AI in their teaching, but they could benefit from further training in: ☐ Knowing about the workings of AI systems; ☐ Recognizing limitations and hallucinations; ☐ Detecting algorithmic bias; ☐ Protecting student data; ☐ Obtaining digital consent; ☐ Evaluating the fairness and validity of AI tools; and ☐ Realigning the use of AI with school policy.

Profile 3: High/Holistic AI Literacy

A total of 209 teachers (43.8% of the sample) were in the third profile. All of these teachers had high scores in all five dimensions. They achieved their best results in AI pedagogy, professional learning, human-centred mindset, AI foundations and ethics. This profile describes teachers who are relatively ready and prepared to ethically and pedagogically use AI in their teaching. They can be appropriate for advanced study, peer mentoring, teacher learning groups, and teacher-leaders.

Multidimensional AI-Literacy Profiles

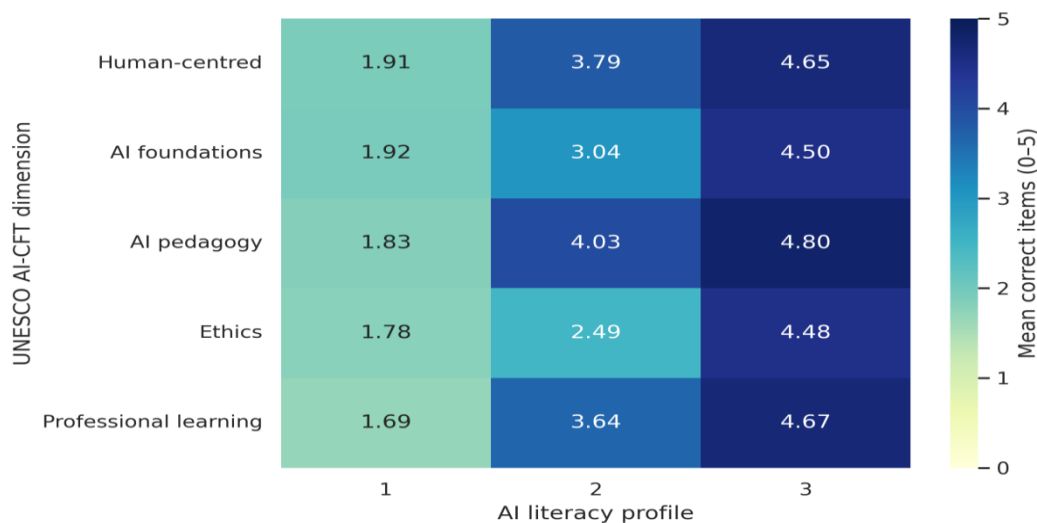


Fig 5: Multidimensional AI-Literacy Profiles

Radar chart comparing the three profiles across the five AI-CFT dimensions. The profile analysis provides a more informative picture than the overall mean alone. It shows that the sample is not homogeneous. While many teachers demonstrate high or moderately strong AI literacy, a distinct group requires foundational intervention. It also shows that moderate AI literacy is often characterized by stronger pedagogical knowledge than ethical or technical knowledge.

Hypothesis-Testing Summary

Table 21: Final Decisions Regarding the Null Hypotheses

Hypothesis	Null hypothesis	Result
H01	No significant difference between male and female teachers	Retained

Hypothesis	Null hypothesis	Result
H02	No significant difference between rural and urban teachers	Retained
H03	No significant difference across age groups	Retained
H04	No significant difference across experience groups	Retained
H05	No significant difference across qualification levels	Retained
H06	No significant difference across selected districts/divisions	Retained at district level

None of the null hypotheses was rejected. This means that the available evidence did not demonstrate statistically significant differences in overall AI literacy across the examined demographic, professional, and geographical categories.

Discussion

The results revealed that the AI literacy level of primary school teachers in Punjab is moderate ($M = 18.39/25$) with significant variations in competency. AI pedagogy received the highest scores and was the dimension that most participants were familiar with, and knew how to apply in the classroom, while AI ethics ($M = 3.25/5$) and AI foundations were relatively lower. This underscores the importance of developing the technical knowledge, ethical consciousness, and critical analysis of teachers in using AI tools and outputs in conjunction with their technical skills. There were no significant difference between male and female, rural/urban, age, teaching experience or qualification, indicating that professional development programs should not target demographics, but be based on the needs of the profession. The differences across districts were also not statistically significant, but descriptive differences suggest there may be other contextual factors that are important to examine. Three teacher profiles of low/limited, pedagogy-oriented moderate, and high/holistic, further illustrate the multi-faceted nature of AI literacy. The results imply that there is an education training approach that is not enough for teachers since they have different needs. Rather, AI professional learning must be differentiated, hands-on, ethical, and ongoing, with additional resources for teachers who need more basic skills and advanced resources for highly proficient teachers.

Conclusion

The overall level of AI literacy of the primary school teachers in Punjab was found to be moderate ($M = 18.39/25$). AI pedagogy was the highest rated, and the lowest rated were AI ethics and AI foundations. There was no difference between male and female, between locations, between ages, between experience and between qualifications, and between the differences at the district level. Three teacher profiles—low/limited, pedagogy-oriented moderate, and high/holistic—showed the multi-dimensionality of AI Literacy. The overall results indicate the importance of structured, ethical, practical, and differentiated professional development of AI for primary school teachers in Punjab.

Recommendations

Create a Competency Based AI Training Program: Ensure the teacher training is relevant and aligned to the 5 areas of UNESCO's AI-CFT, human-centered AI, AI foundations, AI pedagogy, ethics, and professional learning. Focus on AI Ethics and Data Protection: Ensure bias, privacy, consent, transparency, academic integrity, supervision, and verification of AI-generated data are emphasized. Improve AI foundations: Give teachers hands-on experience with AI, Algorithms, Data, Machine Learning, Generative AI, LLMs, bias, and limitations of AI. Implement AI in the Curriculum: Train teachers to use AI practically in Urdu, English, Mathematics, Science, lesson planning, assessment and differentiated instruction with special focus on verifying AI outputs. Differentiated Training: Basic training and mentoring for low literacy teachers, applied pedagogical and ethical training for moderate level teachers, advanced leadership training for highly literate teachers. Create Professional Learning Communities: Enlist other teachers to share their AI practices, create AI resources, discuss ethical issues, and mentor other teachers. Enhance Digital Infrastructure: Provision of electricity, internet, devices, digital infrastructure, secure systems and technical assistance in government schools. Provide Approved AI tools and school policies: Distribute approved privacy, safety, academic integrity, responsible use and student protection policies to schools, and approved AI tools. Monitor Practical AI Competency: Conduct Knowledge Tests, scenario-based activities, lesson-plan reviews, observations, and portfolios periodically for teachers to ensure they are competent in practical application.

Limitations of the Study

This is a cross sectional study that cannot make causal inferences. The objective AI-literacy measurement is not necessarily representative of teachers' actual teaching and the exploratory profile analysis may need replication with larger samples and confirmatory methods. Lastly, the study-specific score bands should not be considered as official UNESCO levels of proficiency.

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