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Assessing the Artificial Intelligence Training Needs of Primary School Teachers in Punjab: A UNESCO AI Competency Framework for Teachers-Based Study

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Abstract

Artificial intelligence (AI) is increasingly transforming educational practice, creating new professional competency requirements for teachers. This study assessed the perceived AI training needs of primary school teachers in Punjab, Pakistan, using the UNESCO AI Competency Framework for Teachers as the guiding framework. A quantitative cross-sectional survey design was employed with a targeted sample of 500 primary school teachers from nine districts representing northern, central, and southern Punjab. Data were collected through a 25-item structured questionnaire covering five UNESCO-aligned domains: human-centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and professional learning. Descriptive statistics, reliability analysis, Welch independent-samples *t*-tests, one-way ANOVA, and descriptive analysis of open-ended responses were conducted. The 25-item scale demonstrated excellent internal consistency (Cronbach's $\alpha = .957$). Overall, teachers reported a moderately high level of perceived AI training need ($M = 6.88$, $SD = 1.96$). Professional learning emerged as the highest-rated domain ($M = 7.01$), followed by AI foundations and applications ($M = 6.91$) and ethics of AI ($M = 6.90$). The highest-priority individual needs were fair AI access for rural schools, maintaining teacher authority when using AI, multimedia resource generation, AI certification, professional learning networks, and AI-integrated lesson planning. No statistically significant differences were found in overall training needs by gender, district, school location, academic qualification, or teaching experience. Open-ended responses further emphasized the need for practical AI training, lesson-planning support, time-saving applications, ethical guidance, and improved digital infrastructure. The findings indicate that AI professional development for primary teachers in Punjab should be continuous, practical, human-centered, ethically grounded, and supported by adequate infrastructure and professional learning opportunities.

Keywords: UNESCO, AI Competency Framework, AI pedagogy

Introduction

Artificial intelligence (AI) is rapidly reshaping teaching, assessment, learning support, and professional work across school systems, which has raised the threshold of competencies expected from teachers beyond conventional digital literacy (Celik et al., 2022; Dou & Zhao, 2025; Aulia et al., 2026). Current literature consistently shows that teacher preparedness for AI now includes

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not only technical operation of tools, but also pedagogical judgment, ethical reasoning, assessment literacy, and sustained professional learning (Aravantinos et al., 2026; Chiu et al., 2024; Guillen, 2026; Vinci et al., 2026). This shift is especially important in primary education, where teachers shape foundational cognitive, social, and ethical learning experiences and where AI-mediated pedagogies must remain developmentally appropriate and human-centered (Hoa et al., 2026; Yim & Su, 2025; Kong & Yang, 2024).

The urgency of this issue has intensified because AI adoption in education has advanced faster than teacher preparation systems. Across contexts, teachers report interest in AI and recognize its potential for personalization, feedback, administrative efficiency, and learner engagement, yet they also describe limited formal preparation, weak institutional guidance, and uncertainty about ethical and pedagogical use (Filiz et al., 2025; Galindo-Domínguez et al., 2024; Ng et al., 2025; Boota et al., 2026). In primary education specifically, systematic reviews show that AI integration is constrained by insufficient training, limited infrastructure, and inadequate institutional support despite teachers' generally positive perceptions of AI's classroom potential (Arranz Garcia, 2025; Erol & Erol, 2024). These patterns suggest that the central problem is no longer simple awareness of AI, but the absence of structured competency development pathways tailored to teachers' real instructional contexts (Guillen, 2026; Mikeladze et al., 2024).

This problem is especially salient in developing and unequal educational settings. Research from South Asia and other Global South contexts shows that AI integration is mediated by infrastructure gaps, uneven access to devices and connectivity, language and cultural mismatches, low institutional readiness, and the absence of localized policy support (Kundu et al., 2025; Yadav, 2026; Gide & Al-Sabbagh, 2026; Matjie et al., 2026; Dhakal et al., 2025). Studies further warn that without targeted capacity building and equity-focused governance, AI can widen rather than reduce existing educational inequalities (Daher, 2025; Arranz Garcia, 2025; Matjie et al., 2026). For Punjab, this concern is not abstract. Emerging evidence from Pakistan indicates that teachers face insufficient training, cost barriers, ethical concerns, low practical exposure, and weak policy implementation support for classroom AI integration (Haq, 2025; Khan et al., 2026; Ghaffar et al., 2026).

The Punjab context is particularly important because policy ambition appears to be moving faster than teacher education practice. Recent qualitative studies from Punjab, Pakistan report that pre-service teachers often encounter AI through informal experimentation rather than formally scaffolded institutional training, and they describe institutional silence, fragmented integration, competence gaps, and ethical uncertainty (Rasheed, 2026; Boota et al., 2026; Anis & Muhammad, 2026). Although these studies focus mainly on pre-service settings, they strongly imply that in-service primary teachers may also be navigating AI adoption without a coherent competency roadmap or validated needs-based professional development structure (Rasheed, 2026; Boota et al., 2026).

In this context, the UNESCO AI Competency Framework for Teachers offers a robust conceptual foundation for assessing teachers' AI-related training needs. The framework organizes teacher competence across five aspects—human-centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning—and three developmental levels: acquire, deepen, and create (Bai, 2025; Mikeladze et al., 2024; Dou & Zhao, 2025). It is explicitly

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designed to promote ethical, safe, effective, and responsible AI use while safeguarding human agency, accountability, and educational purpose (Bai, 2025; Mikeladze et al., 2024; Dou & Zhao, 2025). The framework is therefore well suited to contexts like Punjab, where the main need is not simply more exposure to AI tools, but structured diagnosis of what teachers know, what they can do, what ethical judgments they can make, and what support they require for meaningful professional learning (Bai, 2025; Dou & Zhao, 2025).

A training-needs assessment grounded in this framework is also justified methodologically. Broader professional development research shows that effective teacher learning is strongest when it is based on identified needs, localized realities, and validated assessment tools rather than generic top-down training provision (Salvador, 2024; Recreo & Gonday, 2026; Samim, 2025; Oo et al., 2023). Training-needs analysis tools are widely used internationally because they help identify individual, group, and organizational gaps and support prioritization of scarce professional development resources (Markaki et al., 2021). For a province such as Punjab, where school conditions likely vary by geography, sector, infrastructure, and prior exposure to digital innovation, a systematic needs assessment can provide the empirical basis for differentiated, context-sensitive AI teacher training policy.

Against this background, the present study is justified on four grounds. First, the literature shows strong global demand for teacher AI competence development but continued under-preparation in practice (Tenberga & Daniela, 2024; Delcker et al., 2024; Gerencsér, 2025). Second, primary school teachers require tailored frameworks because their instructional responsibilities and learner age group differ from those of secondary and higher education teachers (Qiu, 2026; Arı, 2026). Third, Pakistan and Punjab remain underrepresented in the empirical literature on teacher AI competencies and training needs (Haq, 2025; Boota et al., 2026; Anis & Muhammad, 2026). Fourth, although UNESCO's framework is increasingly recognized as a global standard, empirical work applying it to diagnose teacher needs in localized school contexts is still emerging (Mikeladze et al., 2024; Shi, 2025; Alasgarova & Rzayev, 2025). Therefore, assessing the AI training needs of primary school teachers in Punjab through the UNESCO AI Competency Framework for Teachers is both empirically necessary and policy relevant.

Literature Review

AI Competence as a Distinct Dimension of Teacher Professionalism

Recent literature shows broad agreement that AI competence should not be reduced to general digital competence. Although digital competence remains positively associated with teachers' attitudes toward AI, AI introduces additional demands related to algorithmic understanding, data use, ethical reflection, assessment, and human-AI collaboration (Galindo-Domínguez et al., 2024; Chiu et al., 2024; Skibińska, 2025). Reviews of teacher AI competence frameworks conclude that many earlier models were either too general or overly technical, creating the need for more explicit competency structures tailored to educators' professional work (Mikeladze et al., 2024; Zou et al., 2025). This is why contemporary work increasingly treats teacher AI competence as multidimensional, combining knowledge, pedagogy, values, professional judgment, and ongoing learning (Delcker et al., 2024; Chiu et al., 2024; Baizhanov et al., 2026).

Online ISSN: 3006-8886
Print ISSN: 3006-8878

A consistent finding across the literature is that teachers often show uneven competence profiles. Technical awareness or willingness to use AI can coexist with weak pedagogical integration, low ethical confidence, or limited professional-learning capacity (Alé et al., 2025; Han, 2025; Oktaviani et al., 2026). This unevenness is important for needs assessment because it means teachers should not be treated as simply "ready" or "not ready." Instead, different competency domains mature at different rates and require differentiated support (Delcker et al., 2024; Qi et al., 2026; Aulia et al., 2026).

UNESCO AI-CFT as an Organizing Framework

The UNESCO AI Competency Framework for Teachers has quickly become one of the most comprehensive reference models for AI-related teacher development. It specifies fifteen competency blocks across five domains and three progression levels, placing human agency, ethics, and sustainable development at the center of AI integration (Bai, 2025; Okada et al., 2025). Comparative work suggests that the UNESCO model improves on older digital frameworks by explicitly incorporating AI ethics, human-centeredness, and professional learning instead of focusing only on technical operation (Daher, 2025; Skibińska, 2025). It is also increasingly used as a basis for measurement, instrument design, and professional development architecture (Dou & Zhao, 2025; Nam & Choi, 2026; Alexandron et al., 2026).

At the same time, the literature notes two limitations. First, the framework is conceptually strong but still requires more empirical contextualization in diverse national settings (Mikeladze et al., 2024; Han, 2025; Qi et al., 2026). Second, it specifies what competencies matter more clearly than how teachers in particular contexts progress through them (Hossain et al., 2026). These limitations do not weaken its usefulness for this study. They strengthen the case for context-specific applications such as a Punjab-based needs assessment.

What Teachers Commonly Need Training In

The strongest cross-study pattern is that teachers need more than tool demonstrations. Systematic reviews and empirical studies converge on five recurrent training needs: foundational AI knowledge, pedagogical integration, ethical and responsible use, assessment-related applications, and continuous professional learning support (Aravantinos et al., 2026; Chiu et al., 2024; Shi, 2025; Seo, 2026). Teachers frequently report weak AI-related content knowledge and technological knowledge, especially when asked to move from general awareness to classroom design and evaluation (Yue et al., 2024; Kundu et al., 2025; Marienko et al., 2026). Ethical competence is also a recurrent need, especially around privacy, bias, misinformation, fairness, transparency, and the preservation of human judgment (Kundu et al., 2025; Ghaffar et al., 2026; Rui et al., 2025; Vinci et al., 2026).

Pedagogical application is a second major gap. Many teachers use AI at substitution level for planning, grading, or content generation, but struggle to redesign learning in deeper ways (Kundu et al., 2025; Qiu, 2026; Han, 2025). Studies focused on primary schooling add that teachers need help designing age-appropriate, subject-sensitive, and ethically guided classroom activities rather than merely importing generic AI outputs into lessons (Han, 2025; Cao, 2026; Arı, 2026). Professional development therefore appears most effective when it combines hands-on practice,

Online ISSN: 3006-8886
Print ISSN: 3006-8878

collaborative reflection, and curricular alignment rather than isolated technical workshops (Deshen et al., 2026; Alexandron et al., 2026; Oo et al., 2023).

Primary School and Punjab-Specific Gaps

Primary education deserves separate attention because the evidence suggests its needs are not identical to those of secondary or higher education. Primary teachers must align AI use with foundational literacy, early cognitive development, interactive pedagogy, and student protection, which makes human-centered and ethical dimensions especially salient (Hoa et al., 2026; Yim & Su, 2025; Erol & Erol, 2024). Research focused on primary teachers identifies recurring challenges of superficial integration, fragmented knowledge, inadequate awareness of ethical risks, and insufficient recognition of AI's educational value (Qiu, 2026; Morze et al., 2023). Reviews of AI literacy in primary schools also show that evidence remains limited and that framework-informed policy and teacher preparation are still developing (Yim & Su, 2025).

For Punjab, the empirical base is still thin but increasingly clear. Pakistani studies report strong teacher interest in AI-focused professional development alongside major barriers in training, cost, institutional support, and ethical governance (Haq, 2025). Punjab-specific pre-service studies describe unstructured AI exposure, fragmented curriculum integration, competence gaps, and institutional silence despite expanding policy rhetoric (Rasheed, 2026; Boota et al., 2026; Anis & Muhammad, 2026). Together, these findings suggest a likely disconnect between policy aspiration and classroom-level capacity that justifies direct assessment of in-service primary teachers' training needs in Punjab.

Training Needs Assessment as the Appropriate Methodological Response

The literature on professional development strongly supports training-needs assessment as the starting point for effective program design. Needs-based approaches identify priority gaps, allow resource targeting, and improve the fit between training content and teachers' actual work conditions (Markaki et al., 2021; Samim, 2025; Oo et al., 2023). Teacher-focused needs studies in other domains repeatedly find that teachers value many competencies highly while reporting lower proficiency, producing actionable discrepancy profiles for intervention design (Viernes, 2025; Allaith, 2025). This logic is highly transferable to AI competency assessment.

Recent AI-specific measurement studies reinforce this methodological direction. Several validated or emerging instruments now operationalize teacher AI competence across domains such as AI knowledge, pedagogy, ethics, human-centered education, assessment, and professional engagement (Chiu et al., 2024; Shi, 2025; Nam & Choi, 2026). Yet the evidence also shows that assessment systems remain underdeveloped in many settings and need adaptation to local culture, school conditions, and teacher roles (Dou & Zhao, 2025; Nguyen & Phạm, 2023). For Punjab primary schools, a UNESCO-based needs assessment can therefore fill both a practical and scholarly gap by generating context-sensitive baseline evidence for future policy, professional development, and instrument refinement.

Conclusion

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The literature supports a clear conclusion: primary school teachers in Punjab are likely to need structured AI training across human-centered values, ethics, foundational knowledge, pedagogy, and professional learning, and the UNESCO AI Competency Framework for Teachers provides a credible structure for assessing those needs. The most important shift in the literature is the move from treating AI as a tool issue to treating it as a multidimensional teacher-competence issue, while the biggest open question is how global AI competency frameworks should be localized for under-resourced primary school systems such as Punjab.

Research Objectives

RO1: To assess the perceived AI training needs of primary school teachers in Punjab across the five domains of the UNESCO AI Competency Framework for Teachers.

RO2: To identify and prioritize the AI competency areas requiring professional development among primary school teachers in Punjab.

RO3: To examine whether significant differences exist in teachers' perceived AI training needs based on selected demographic and professional characteristics.

RO4: To determine the implications of identified AI training needs for designing contextually relevant professional development for primary school teachers in Punjab.

Research Questions

1. What are the perceived AI training needs of primary school teachers in Punjab across the five domains of the UNESCO AI Competency Framework for Teachers?

2. Which AI competency areas are perceived as the highest-priority training needs among primary school teachers in Punjab?

3. Are there significant differences in primary school teachers' perceived AI training needs based on selected demographic and professional characteristics?

4. What implications do the identified AI training needs have for the professional development of primary school teachers in Punjab?

Research Hypothesis

H_o1: There are no statistically significant differences in the perceived AI training needs of primary school teachers in Punjab based on selected demographic and professional characteristics.

H_o1a: There is no statistically significant difference in perceived AI training needs based on gender.

Online ISSN: 3006-8886
Print ISSN: 3006-8878

H_o1b: There is no statistically significant difference in perceived AI training needs based on geographical region.

H_o1c: There is no statistically significant difference in perceived AI training needs based on rural/urban school location.

H_o1d: There is no statistically significant difference in perceived AI training needs based on academic qualification.

H_o1e: There is no statistically significant difference in perceived AI training needs based on teaching experience.

Methodology

Research Design

The study employed a quantitative cross-sectional survey design to assess the perceived artificial intelligence (AI) training needs of primary school teachers in Punjab, Pakistan. The study was guided by the UNESCO AI Competency Framework for Teachers (AI CFT), comprising five domains: Human-centred Mindset, Ethics of AI, AI Foundations and Applications, AI Pedagogy, and AI for Professional Learning.

Population and Sample

The target population comprised primary school teachers in Punjab. A sample of 500 teachers was targeted from nine districts representing three geographical regions: Jhelum, Chakwal, and Rawalpindi from the North; Lahore, Kasur, and Sheikhupura from the Central region; and Multan, Khanewal, and Vehari from the South. A multistage stratified sampling approach was used, with representation considered across geographical region, rural/urban location, and gender.

Instrument

Data were collected through a structured questionnaire based on the UNESCO AI CFT. The training-needs scale comprised 25 items, with five items representing each UNESCO domain. Items assessed teachers' perceived need for training in specific AI-related competencies. Responses were recorded on a 10-point rating scale (1 = very low training need to 10 = very high training need). Content validity was established through review by experts in education, educational technology, and AI in education. The instrument was pilot tested, and Cronbach's alpha was calculated to establish internal consistency.

Data Collection

After obtaining the necessary administrative permissions, the questionnaire was distributed electronically through relevant higher and district-level education authorities. The authorities facilitated dissemination of the Google Form among primary school teachers in the selected districts.

Online ISSN: 3006-8886
Print ISSN: 3006-8878

Participation was voluntary, and respondents were informed about the purpose and confidentiality of the study.

Data Analysis

Data were analyzed using SPSS. Frequencies, percentages, means, and standard deviations were calculated to determine overall and domain-wise training needs. Item and domain mean scores were ranked to identify priority training areas. Independent-samples t-tests were used for two-group comparisons, such as gender and rural/urban location, while one-way ANOVA was used for variables with three or more groups, including region, qualification, and teaching experience. Statistical significance was assessed at $p < .05$.

Ethical Considerations

Participation was voluntary, and respondents were informed about the academic purpose of the study. Confidentiality and anonymity were maintained, and the collected data were used solely for research purposes.

Data Analysis Method

The 25 training-needs items were organized into five domains based on the UNESCO AI Competency Framework for Teachers: human-centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and professional learning. Domain scores were calculated from the means of their respective five items, while the overall AI training-needs score was calculated from all 25 items. Data analysis included frequencies and percentages for demographic characteristics, means and standard deviations for individual items and domains, Cronbach's alpha for reliability, Welch independent-samples *t*-tests for two-group comparisons, one-way ANOVA for variables with more than two groups, and descriptive analysis of open-ended responses. Statistical significance was assessed at $\alpha = .05$.

Respondent Profile

Table 1: ***Demographic Characteristics of Respondents***

Variable	Category	n	%
Gender	Female	344	66.5
	Male	133	25.7
	Missing	40	7.7
School location	Rural	361	69.8
	Urban	116	22.4
	Missing	40	7.7
Age	25–35 years	175	33.8
	35–45 years	204	39.5
	45–55 years	77	14.9
	55 years and above	21	4.1
	Missing	40	7.7

Online ISSN: 3006-8886
Print ISSN: 3006-8878

Qualification	BA/BSc/B.Ed	55	10.6
	MA/MSc/M.Ed	325	62.9
	MPhil and professional qualification	94	18.2
	PhD and professional qualification	3	0.6
	Missing	40	7.7
Teaching experience	5–10 years	220	42.6
	10–15 years	134	25.9
	15–25 years	84	16.2
	More than 25 years	39	7.5
	Missing	40	7.7

The sample was predominantly female and rural. Most teachers held a master's-level qualification, and the largest experience group consisted of teachers with 5–10 years of teaching experience.

Reliability Analysis

Table 2: ***Reliability of the AI Training-Needs Scale***

Scale/domain	Number of items	Cronbach's α
Human-centered mindset	5	.892
Ethics of AI	5	.918
AI foundations and applications	5	.919
AI pedagogy	5	.922
Professional learning	5	.803
Overall scale	**25**	**.957**

The 25-item scale demonstrated excellent internal consistency with Cronbach's α = .957. The subscale reliability coefficients ranged from .803 to .922, indicating acceptable to excellent reliability.

What are the perceived AI training needs of primary school teachers in Punjab across the five domains?

Table 3: ***Perceived AI Training Needs by UNESCO-Aligned Domain***

Rank	Domain	Mean	SD	Interpretation
1	Professional learning	7.01	2.09	Highest need
2	AI foundations and applications	6.91	2.35	High need
3	Ethics of AI	6.90	2.35	High need
4	AI pedagogy	6.84	2.28	High need
5	Human-centered mindset	6.78	2.27	High need
	Overall scale	**6.88**	**1.96**	**Moderately high need**

The results indicate that teachers reported moderately high AI training needs across all five domains. The highest domain was professional learning (***M*** = 7.01, ***SD*** = 2.09), followed by AI foundations and applications (***M*** = 6.91, ***SD*** = 2.35) and ethics of AI (***M*** = 6.90, ***SD*** = 2.35).The lowest

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domain was human-centered mindset (***M*** = 6.78, ***SD*** = 2.27). However, this should not be interpreted as a low need. Its mean still indicates a substantial perceived requirement for training.The findings suggest that primary school teachers in Punjab do not view AI competence as only a technical matter. Instead, they require development across:

- Practical professional-learning opportunities
- Knowledge of AI concepts and tools
- Ethical and responsible use
- AI-supported teaching practices
- Human judgment and teacher authority

This supports the idea that AI-related professional development should be comprehensive rather than limited to basic computer training or demonstrations of individual AI applications.

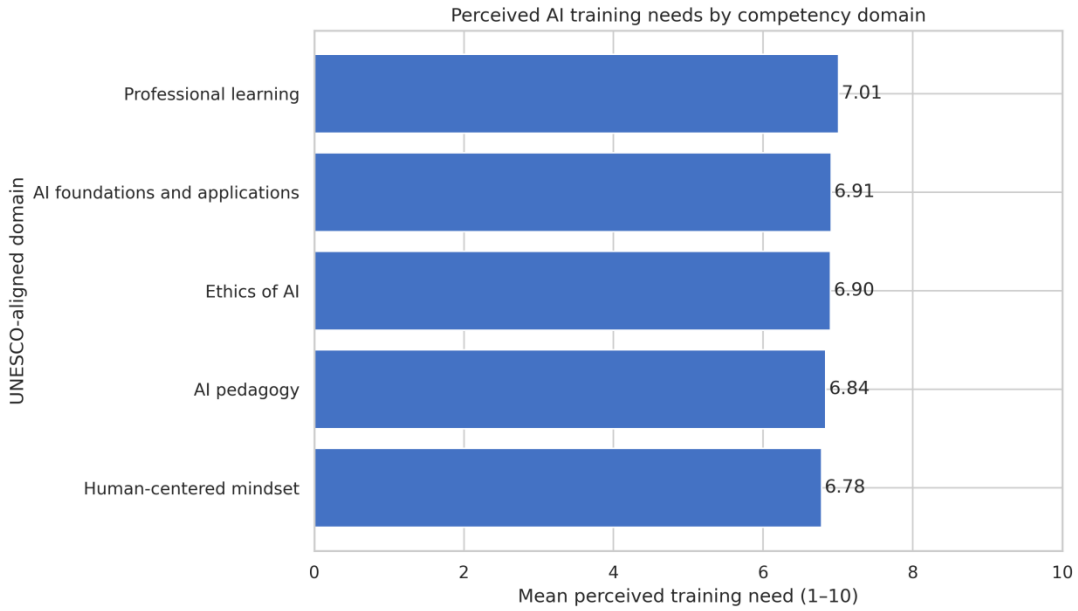


Figure 1: ***Mean Training Need by Domain***

Research Question 2

Which AI competency areas are perceived as the highest-priority training needs?

Table 4: ***Ranking of the 25 AI Training-Need Items***

Rank	Training need	Mean	SD
1	Strategies for ensuring fair AI access for rural schools	7.29	2.65

Online ISSN: 3006-8886
Print ISSN: 3006-8878

2	Training on maintaining teacher authority when using AI	7.23	2.84
3	Training on generating multimedia resources	7.14	2.64
4	Certification courses for AI-ready primary educators	7.07	2.71
5	Access to professional learning networks for AI	7.06	2.69
6	Updates on the latest AI tools for primary education	7.04	2.70
7	Examples of AI-integrated literacy and mathematics lesson plans	7.03	2.65
8	Mentorship programs for AI-advanced teachers	7.01	2.64
9	Practical training on advanced prompt engineering	7.01	2.74
10	Rubrics for evaluating AI educational applications	6.96	2.58
11	Guidelines on ethical grading using AI	6.94	2.69
12	Technical workshops on large language models	6.93	2.77
13	Workshops on safe AI exploration for primary students	6.90	2.77
14	Training for automating teacher paperwork	6.88	2.73
15	Instruction on the environmental impact of AI	6.83	2.66
16	Training on student–AI collaborative projects	6.81	2.60
17	Support for redesigning homework to be AI-resistant	6.81	2.59
18	Guidance on balancing AI automation with human empathy	6.81	2.57
19	Subscriptions to premium AI tools for classroom testing	6.78	2.64
19	Knowledge sessions on Big Data and primary education	6.78	2.65
21	Support for managing social-emotional effects of AI	6.77	2.65
22	Workshops on identifying AI-driven bias in children's learning	6.69	2.76
23	Methods for using AI as a one-to-one student tutor	6.57	2.68
24	Training on identifying and reporting AI hallucinations	6.55	2.75
25	Training to foster critical thinking against AI "truth"	6.40	2.77

The highest-priority training need was ensuring fair AI access for rural schools (***M*** = 7.29). This is important because the sample was largely rural, and it shows that teachers understand AI integration as an issue of infrastructure, availability, and educational equity.

The second-highest priority was maintaining teacher authority (***M*** = 7.23). This demonstrates that teachers want to retain professional judgment and human control when using AI. Teachers appear to support AI as an assistant rather than as a replacement for professional decision-making.

The third-highest need was generating multimedia resources (***M*** = 7.14), suggesting demand for practical skills that can reduce workload and improve lesson presentation.

Other high-priority areas included:

- AI certification
- Professional learning networks
- Current information about AI tools
- AI-integrated literacy and mathematics lesson planning

Online ISSN: 3006-8886
Print ISSN: 3006-8878

- Mentorship
- Prompt engineering
- Evaluation of AI applications

The comparatively lower-ranked items should not be regarded as unimportant. Rather, they may reflect areas that teachers currently understand less clearly or do not yet perceive as immediate classroom priorities.

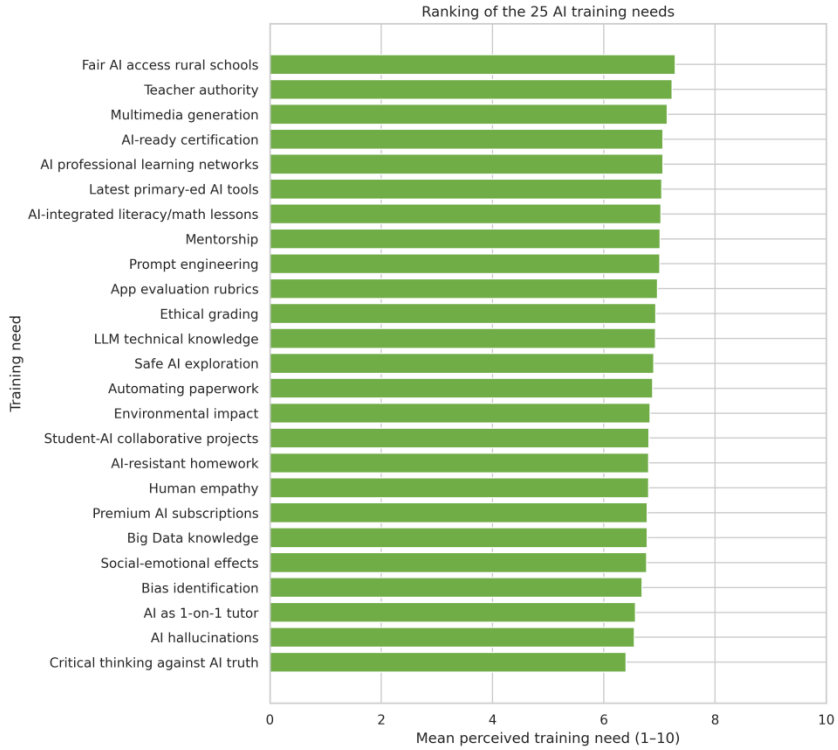


Figure 2: ***Ranking of Individual AI Training Needs***

Research Question 3

Are there significant differences in perceived AI training needs based on demographic and professional characteristics?

The overall AI training-needs score was compared across gender, district, school location, academic qualification, and teaching experience.

Table 5: ***Descriptive Statistics by Demographic and Professional Characteristics***

Gender

Gender	N	Mean	SD

Online ISSN: 3006-8886
Print ISSN: 3006-8878

Female	344	6.87	1.96
Male	133	6.94	1.73

District

District	n	Mean	SD
Multan	48	7.18	2.01
Rawalpindi	84	7.10	1.72
Jhelum	30	7.08	1.63
Lahore	70	7.07	1.90
Khanewal	33	6.91	1.82
Vehari	83	6.82	1.99
Sheikhupura	66	6.79	2.01
Chakwal	39	6.44	1.72
Kasur	24	6.03	2.21

School Location

School location	n	Mean	SD
Rural	361	6.88	1.91
Urban	116	6.91	1.86

Academic Qualification

Qualification	n	Mean	SD
MPhil and professional	94	7.17	1.88
MA/MSc/M.Ed	325	6.88	1.92
BA/BSc/B.Ed	55	6.54	1.82
PhD and professional	3	6.12	0.36

Teaching Experience

Experience	n	Mean	SD
5–10 years	220	7.02	1.96
10–15 years	134	6.86	1.87
15–25 years	84	6.75	1.80
More than 25 years	39	6.59	1.87

Table 6: Tests of Differences in Overall AI Training Needs

Hypothesis	Comparison	Test statistic	p-value	Decision
$H_0$1a	Gender	Welch $t = -0.395$	.693	Retain $H_0$1a
$H_0$1b	District/region	$F(8, 468) = 1.308$	.237	Retain $H_0$1b
$H_0$1c	Rural/urban location	Welch $t = -0.151$	.880	Retain $H_0$1c
$H_0$1d	Academic qualification	$F(3, 473) = 1.507$	.212	Retain $H_0$1d
$H_0$1e	Teaching experience	$F(3, 473) = 0.823$	.481	Retain $H_0$1e

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Online ISSN: 3006-8886
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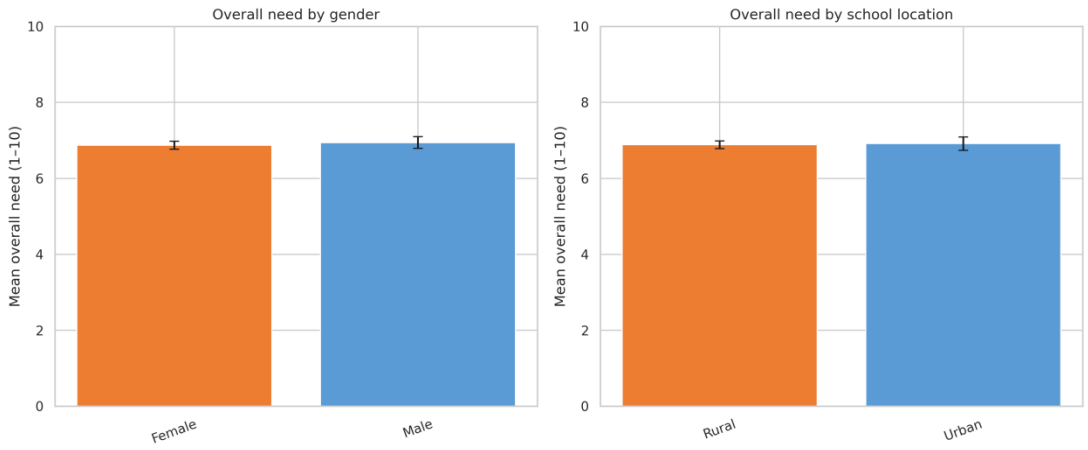


Figure 3: ***Overall Training Need by Gender and School Location***

Results for the Hypotheses

H₀1a: Gender

There was no statistically significant difference between female and male teachers in overall perceived AI training needs, Welch $t = -0.395$, $p = .693$.

Therefore, **H₀1a was retained**.

H₀1b: Geographical Region

The one-way ANOVA showed no statistically significant difference among teachers from the nine districts, $F(8, 468) = 1.308$, $p = .237$.

Therefore, **H₀1b was retained**.

H₀1c: Rural/Urban School Location

There was no statistically significant difference between rural and urban teachers, Welch $t = -0.151$, $p = .880$.

Therefore, **H₀1c was retained**.

H₀1d: Academic Qualification

The differences among qualification groups were not statistically significant, $F(3, 473) = 1.507$, $p = .212$.

Therefore, **H₀1d was retained**.

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H_o1e: Teaching Experience

The differences among experience groups were not statistically significant, $F(3, 473) = 0.823$, $p = .481$.

Therefore, **H_o1e was retained**.

The results indicate that AI training needs are widely shared across the teacher population. Gender, district, rural/urban location, academic qualification, and teaching experience did not produce statistically significant differences in the overall training-needs score.

This suggests that the Punjab School Education Department could implement a common foundational AI-training programme for all primary school teachers. Differentiated training may still be useful, but it should be based on individual competency levels and school resources rather than on demographic characteristics alone.

Research Question 4

What implications do the identified AI training needs have for professional development?

The findings have several implications for the professional development of primary school teachers in Punjab.

Implications for AI Teacher Training

The findings indicate that AI professional development should be continuous rather than limited to one-time workshops. Teachers need ongoing professional learning through refresher training, mentoring, peer learning, professional networks, certification, and regular updates on emerging AI tools. Training should also be accompanied by adequate infrastructure, particularly in rural schools, including reliable electricity, internet connectivity, digital devices, technical support, and low-bandwidth or offline resources. The strong emphasis on maintaining teacher authority highlights the need for a human-centred approach in which teachers retain professional judgment and oversight while using AI as a supportive tool rather than a replacement for human decision-making.

Furthermore, professional development should be practical and classroom-oriented, focusing on AI-supported literacy and mathematics lessons, multimedia and worksheet creation, differentiated learning materials, assessment, lesson preparation, and administrative tasks. Ethical considerations should be integrated throughout the training, including privacy, consent, bias, fairness, transparency, child safety, responsible use of AI-generated content, and teacher accountability. Teachers should also develop practical skills in prompt engineering and AI-output evaluation, including writing effective prompts, checking accuracy, identifying bias and hallucinations, ensuring age appropriateness, aligning AI-generated materials with curriculum objectives, and protecting students' personal information. Overall, AI training should combine continuous professional learning, infrastructure support, human-centred practice, classroom application, ethical awareness, and AI evaluation skills.

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Print ISSN: 3006-8878

Analysis of Open-Ended Responses

A total of 481 open-ended responses were available for analysis.

Table 7: ***Common Themes in Open-Ended Suggestions***

Theme	Approximate number of responses mentioning theme
Training	259
AI tools	103
Lesson planning or lessons	118
Time-saving uses	63
Prompting or prompt engineering	29
Ethics or ethical use	28
Workshops	21
Computer access	13
Computer laboratory	12
Internet/connectivity	10

The open-ended responses reinforced the quantitative findings, with teachers emphasizing the need for practical AI training, workshops, lesson-planning support, time-saving applications, prompt engineering, ethical guidance, and access to classroom resources. They also highlighted the importance of basic infrastructure, particularly computer facilities and reliable internet connectivity, as essential conditions for effective AI integration in schools.

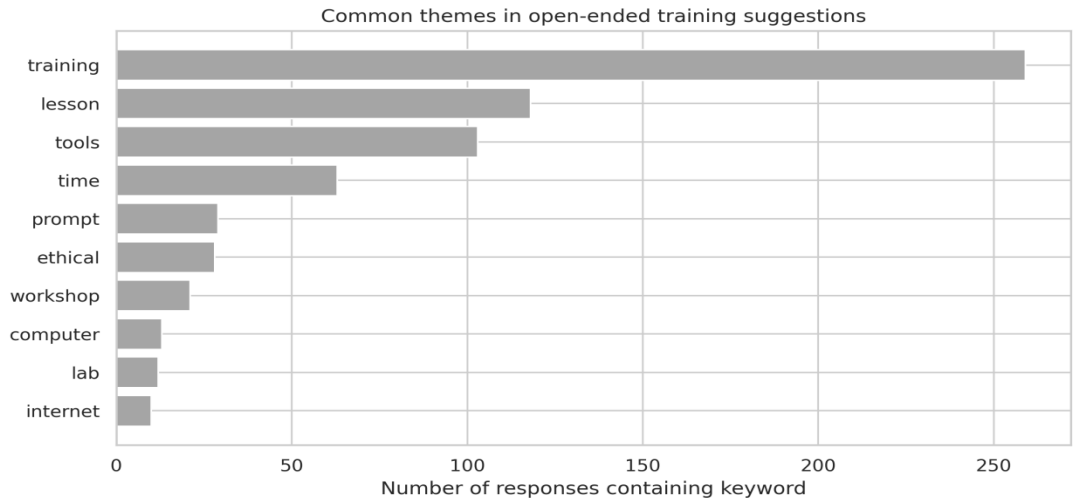


Figure 4: ***Common Themes in Teachers' Open-Ended Suggestions***

Discussions

The findings indicate that primary school teachers in Punjab perceive AI competence as a broad and multidimensional professional need, reflected in the moderately high overall training-need mean of 6.88 out of 10. Professional learning emerged as the highest-rated domain, highlighting

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teachers' demand for continuous development through certification, mentorship, professional learning networks, and regular updates. The highest-ranked need for equitable AI access in rural schools further demonstrates that AI readiness depends not only on teacher competence but also on institutional infrastructure, including devices, internet connectivity, electricity, and technical support.

The strong emphasis on maintaining teacher authority reinforces the importance of a human-centred approach in which AI supports, rather than replaces, teachers' professional judgment. High demand for multimedia generation and AI-supported literacy and mathematics lessons also indicates a preference for practical, curriculum-linked training that produces immediately usable classroom resources. The absence of significant differences by gender, district, school location, qualification, and teaching experience suggests that AI training needs are broadly shared across teacher groups. However, the lack of rural–urban differences in perceived need should not be interpreted as equal access to AI resources, as rural teachers may face greater infrastructural constraints. Likewise, qualification and experience alone do not appear sufficient to ensure AI competence, emphasizing the need for targeted professional learning. Open-ended responses further supported the quantitative findings, with teachers emphasizing practical training, classroom resources, ethical guidance, time-saving applications, workshops, and improved digital infrastructure. Overall, the findings suggest that effective AI professional development in Punjab should be practical, continuous, equitable, human-centred, and supported by adequate infrastructure.

Conclusion

The study examined the perceived AI training needs of primary school teachers in Punjab across five UNESCO-aligned domains.

The major conclusions are:

1. Teachers reported moderately high AI training needs across all five domains.
2. Professional learning was the highest-rated domain.
3. The highest individual priority was ensuring fair AI access for rural schools.
4. Maintaining teacher authority was the second-highest priority.
5. Multimedia generation, AI certification, professional learning networks, and updated AI tools were also highly prioritized.
6. No statistically significant differences were found based on gender, district, rural/urban school location, academic qualification, or teaching experience.
7. The findings support a universal AI professional-development programme for primary school teachers.
8. Such a programme must be supported by computer laboratories, internet connectivity, devices, mentoring, and continuous follow-up.

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Print ISSN: 3006-8878

9. AI training should emphasize ethical, human-centered, classroom-relevant, and workload-reducing applications.

Overall, AI professional development for primary school teachers in Punjab should not be limited to technical knowledge. It should develop teachers' ability to use AI responsibly, critically, creatively, and in alignment with curriculum objectives and the needs of young learners.

Recommendations

Based on the findings, the Punjab School Education Department should establish a province-wide AI competency programme for primary school teachers, supported by a common foundational module covering AI concepts, responsible use, ethics, privacy, bias, hallucinations, and human oversight. Since no significant differences were observed across teachers' demographic and professional characteristics, foundational AI training may be provided to all teachers, while allowing further specialization according to contextual needs. Particular attention should be given to rural schools through improved internet connectivity, electricity and backup power, shared digital devices, offline training resources, technical support, and access to approved educational AI platforms.

AI training should be practical, curriculum-linked, and focused on classroom applications such as AI-supported lesson planning, differentiated learning, multimedia and worksheet development, assessment, remedial instruction, and administrative tasks. District-level mentoring networks could further support implementation by preparing trained mentor teachers to provide peer guidance, demonstrate effective practices, and share resources. A competency-based certification pathway may also be introduced to recognize teachers who demonstrate proficiency in responsible AI use, prompt engineering, evaluation of AI outputs, lesson planning, assessment, and ethical classroom implementation.

AI professional development should consistently incorporate child protection and ethical considerations, including student data privacy, consent, algorithmic bias, fairness, transparency, and human oversight. Training programmes should also be systematically evaluated through measures of teachers' AI knowledge and confidence, classroom application, quality of AI-supported teaching, administrative workload, student engagement, equity of access, and ethical compliance. Future research should employ larger representative samples, probability sampling, pre-test and post-test designs, classroom observations, qualitative methods, infrastructure measures, longitudinal approaches, and comparative studies across provinces to provide stronger evidence regarding the effectiveness and sustainability of AI teacher training.

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