

Development of a training model for enhancing artificial intelligence skills of teachers in primary schools in Yunnan Province

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Accepted 28 October, 2026

ABSTRACT

This study aimed to (1) assess the professional-development needs of primary school teachers in Yunnan Province regarding artificial intelligence (AI) competencies, (2) develop an expert-informed 4T AI Training Model, and (3) compare achievement-test scores immediately before and after a preliminary training implementation. The sequential three-phase study included a needs survey of 400 teachers selected through a reported two-stage school-and-teacher sampling procedure, a focus-group review involving nine purposively selected specialists, and a one-group pre-test/post-test evaluation of 32 teachers. Instruments included a five-point needs-assessment questionnaire, a focus-group discussion form, and a 50-item achievement test. Descriptive statistics, the modified Priority Needs Index (PNI_modified), content analysis, and a paired-samples t-test were used. The overall current-condition rating was low ($M = 2.37$, $SD = 0.65$), whereas the desired-condition rating was high ($M = 3.99$, $SD = 1.12$); the reported overall PNI_modified was 0.68. Priority needs included AI Collaboration, Classroom Management with AI, Problem-Solving with AI Tools, AI Assessment and Evaluation, and Instructional Integration. The 4T model comprised Training Content, Training Methods, Training Resources, and Training Evaluation, structured across Basic, Application, and Development stages. Overall achievement-test scores rose from a reported pre-test mean of 30.69 ($SD = 1.64$) to a post-test mean of 41.19 ($SD = 2.95$), $t(31) = 25.36$, $p < .001$. This represents higher short-term test scores after training; without a comparison group or delayed follow-up, the findings do not establish a causal effect or sustained improvement in classroom practice.

Keywords: Training model, artificial intelligence skills, primary school teachers, Yunnan Province, teacher professional development.

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INTRODUCTION

Artificial intelligence (AI) is changing teachers' responsibilities for lesson planning, instruction, feedback, classroom assessment, and professional learning. Effective educational use requires more than familiarity with software: teachers must evaluate AI-generated outputs, protect pupil information, identify bias, and make independent pedagogical decisions (Walter, 2024; Gouseti et al., 2025). In Yunnan Province, geographic and school-level variation in training opportunities and technology access makes context-sensitive teacher professional development particularly important. Consequently, teacher training should connect foundational AI knowledge with supported classroom applications rather than

emphasize isolated technical demonstrations.

Current frameworks provide useful guidance but do not automatically address local implementation needs. UNESCO's AI Competency Framework for Teachers identifies human-centred practice, ethics, AI foundations and applications, AI pedagogy, and AI for professional learning; its Acquire, Deepen, and Create progression illustrates how competencies can develop over time (Miao and Cukurova, 2024). A systematic review of AI in teaching and teacher professional development highlights the need for greater attention to educators' ongoing preparation (Tan et al., 2025). These approaches inform this study's staged professional-learning rationale but do not serve

as evidence of effectiveness in Yunnan schools.

Primary school teachers must select suitable AI tools, adapt generated content to children's learning needs, monitor classroom interactions, and use AI-supported assessment responsibly. Teachers working with varied curricula, student languages, and available resources may require different forms of support. Research with teacher educators has emphasized practical learning, collaboration, and an understanding of AI-related ethical responsibilities (Prilop et al., 2025). These considerations suggest that professional development should combine content knowledge, pedagogical rehearsal, technical resources, mentoring, and opportunities for evaluation and reflection.

The present study distinguishes ten operational AI competency dimensions: Technological Knowledge and Application, Data Literacy, Critical and Ethical Awareness, Professional Development in AI, Problem-Solving with AI Tools, AI Assessment and Evaluation, AI Collaboration, Instructional Integration, Classroom Management with AI, and Reflection and Adaptation. For conceptual presentation, the dimensions can be grouped into three categories: Knowledge (technological knowledge, data literacy, and ethics), Practice (collaboration, integration, classroom management, and assessment), and Development (professional learning, problem-solving, and reflection). These categories organize the training goals; they are not independently validated statistical factors.

The Knowledge, Practice, and Development competency categories should be distinguished from the three successive delivery stages of the 4T model: Basic, Application, and Development. The Basic stage introduces AI concepts and responsible use; the Application stage concentrates on lesson tasks, classroom problems, and microteaching; and the Development stage emphasizes collaborative improvement, reflective practice, and continued professional learning. The four 4T components—Training Content, Training Methods, Training Resources, and Training Evaluation—operate across all three stages, supported by teachers, schools and peers, and external experts or technical providers.

The research gap addressed here is the limited evidence linking a locally grounded assessment of AI competency needs among Yunnan primary school teachers to the design, specialist review, and preliminary assessment of an integrated training programme. General competency frameworks identify important principles, but schools also need practical decisions about what to teach, how to organize practice, what resources to provide, and how to review progress. Accordingly, this study first identified reported priorities, then developed a needs-informed training structure with expert input, and finally examined an overall achievement-test outcome in a smaller cohort.

The study makes a preliminary design and evaluation contribution rather than claiming definitive programme effectiveness. The provincial needs assessment describes the perceived difference between current and desired

competency levels; specialist consultation informs the proposed model; and the one-group pre-test/post-test comparison describes short-term test-score change. The distinction among these sources of evidence is essential, because neither the questionnaire nor the immediate achievement test directly measures long-term teaching quality, student learning, or reduced disparities between schools.

Research questions

1. What artificial intelligence competency development needs are reported by primary school teachers in Yunnan Province?
2. How can a needs-informed 4T training model be developed and reviewed by specialists for these teachers?
3. How do teachers' overall AI achievement-test scores differ immediately before and after participation in the preliminary training?

Research objectives

1. To assess the current and desired AI competencies of primary school teachers in Yunnan Province and determine priority training needs.
2. To develop and review a 4T AI Training Model informed by those needs and specialist recommendations.
3. To compare overall AI achievement-test scores before and immediately after implementation in a pilot group of teachers.

Conceptual framework

The conceptual framework links the proposed 4T AI Training Model to ten intended AI competency dimensions among primary school teachers in Yunnan Province. The model's four integrated components are Training Content (what teachers learn), Training Methods (how they practise), Training Resources (the support they use), and Training Evaluation (how learning is reviewed). The learning sequence progresses through Basic, Application, and Development stages. These elements are intended to support the development of AI competencies; the framework does not itself establish an experimentally verified causal relationship.

The ten competency dimensions shown in Figure 1 are Technological Knowledge and Application, Data Literacy, Critical and Ethical Awareness, Professional Development in AI, Problem-Solving with AI Tools, AI Assessment and Evaluation, AI Collaboration, Instructional Integration, Classroom Management with AI, and Reflection and Adaptation. Conceptually, they are summarized as Knowledge, Practice, and Development outcomes. The original figure displays the ten dimensions individually; the

grouping provides explanatory organization, not a tested three-factor measurement structure. Overall achievement

scores, rather than separate changes in each dimension, were evaluated in Phase 3.

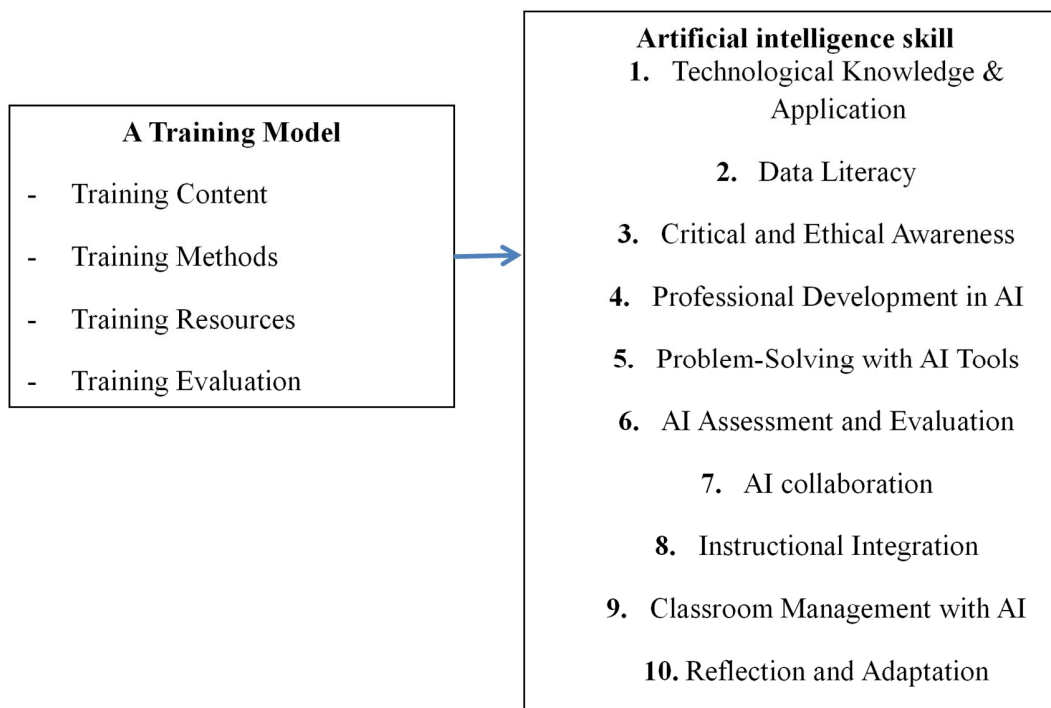


Figure 1. Conceptual framework.

METHODOLOGY

A sequential three-phase design was employed: Phase 1 assessed provincial AI competency development needs, Phase 2 developed and reviewed a training model, and Phase 3 examined short-term achievement-test changes in a separate preliminary implementation cohort. The 400-teacher questionnaire sample and the 32-teacher training cohort served different purposes and should not be interpreted as one longitudinal sample.

Phase 1

The study population was reported as 220,977 primary school teachers across 9,913 primary schools in Yunnan Province. With Yamane's formula, $n = N/(1 + Ne^2)$, a precision level of .05 yields a target of approximately 400. A two-stage design was described: schools were selected using probability proportional to size (PPS), followed by stratified random selection of teachers within selected schools. The survey collected respondent characteristics and current and desired ratings for ten AI competency dimensions using a five-point Likert-type scale (1 = strongly disagree to 5 = strongly agree). The report did not specify the number of participating schools, stratum

allocations, response rate, or any sampling-design adjustment.

Phase 2

Nine specialists were purposively selected for a focus-group discussion on educational administration, teacher professional development, curriculum, educational technology, and AI in education. The group considered the proposed model's content, instructional methods, resources, feasibility, ethical safeguards, implementation process, and evaluation. Their recommendations were synthesized through content analysis and used to refine the four components of the model. Specialist review provided evidence of practical and content relevance, not a quantitative validation of the ten-dimensional competency structure.

Phase 3

A cohort of 32 teachers completed a 50-item AI achievement test immediately before and after preliminary training. The report identifies participants from eight areas: Kunming Yuhua, Dali Cangshan, Lijiang Ancient Town,

Qujing Qilin, Yuxi Hongta, Baoshan Longyang, Pu'er Simao, and Honghe Mengzi. The number recruited per area and the detailed recruitment mechanism were not specified. This was a single-group pre-test/post-test evaluation, not a randomized controlled trial. The small cohort was used for preliminary outcome assessment and does not represent a province-wide intervention-effect estimate.

The instruments were a needs assessment questionnaire, a focus-group discussion form, and a 50-item achievement test. Item relevance was described as subject to expert review using the Index of Item–Objective Congruence (IOC), with KR-21 or Cronbach's alpha identified as potential reliability procedures; numerical validation and reliability coefficients and item difficulty/discrimination indices were not reported. Descriptive statistics summarized the needs survey. The modified Priority Needs Index was defined as $PNI_modified = (I - D)/D$, where I is the desired-condition mean and D the current-condition mean. Focus-group input was analysed qualitatively. Overall test scores were compared using the paired-samples t-test (two-sided, $df = 31$). Results are presented in aggregate form, without identifying

participants; formal ethics approval and informed-consent details were not specified in the study documentation.

RESULTS

The results are organized according to the three research objectives described above.

Results for Objective 1: Assessment of current and desired AI competencies among primary school teachers in Yunnan Province.

Table 1 presents the original study's current-condition ratings, desired-condition ratings, and modified Priority Needs Index (PNI_modified) by competency dimension. The reported overall current condition was low ($M = 2.37$, $SD = 0.65$), whereas the desired condition was high ($M = 3.99$, $SD = 1.12$). The reported overall PNI_modified was 0.68, indicating a substantial perceived gap. PNI_modified is a descriptive ratio based on mean ratings; it is not a test of statistical differences between domains.

Table 1. Needs assessment of artificial intelligence competencies among primary school teachers in Yunnan Province ($n = 400$).

Topic	Status (D)			Expected conditions (I)			PNI	Meaning	Order
	$\bar{x}$	S.D.	Level	$\bar{x}$	S.D.	Level			
Technological Knowledge & Application	2.54	0.66	Moderate	3.79	1.18	High	0.49	High level	10
Data Literacy	2.49	0.65	Low	3.77	1.25	High	0.51	High level	8
Critical and Ethical Awareness	2.43	0.65	Low	4.11	1.04	High	0.69	High level	6
Professional Development in AI	2.40	0.66	Low	3.93	1.16	High	0.64	High level	7
Problem-Solving with AI Tools	2.35	0.66	Low	4.13	1.06	High	0.75	High level	3
AI Assessment and Evaluation	2.30	0.66	Low	4.02	1.09	High	0.75	High level	4
AI Collaboration	2.26	0.65	Low	4.31	0.96	High	0.90	High level	1
Instructional Integration	2.22	0.64	Low	3.88	1.20	High	0.75	High level	5
Classroom Management with AI	2.22	0.65	Low	4.18	1.05	High	0.89	High level	2
Reflection and Adaptation	2.53	0.66	Moderate	3.78	1.16	High	0.49	High level	9
Overall	2.37	0.65	Low	3.99	1.12	High	0.68	High level	-

The five highest-ranked needs were AI Collaboration (PNI_modified = 0.90), Classroom Management with AI (0.89), Problem-Solving with AI Tools (0.75), AI Assessment and Evaluation (0.75), and Instructional Integration (0.75). These results suggest that priority training content should connect AI tools with collaborative work, classroom routines, instructional decision-making, and assessment. The figures and ranks in Table 1 are retained as reported in the original manuscript.

Results for Objective 2: Development and specialist review of the 4T AI Training Model

The initial training model was developed from the needs-assessment priorities and refined through discussion with nine specialists. As summarized in Table 2, it comprised Training Content, Training Methods, Training Resources, and Training Evaluation. The specialists highlighted the value of practice-oriented tasks, collaborative activities, appropriate tools and mentoring, performance feedback, responsible AI use, and opportunities to reflect on

implementation. Their appraisal addressed coherence and practical relevance; it did not establish statistical validity or independent evidence of improvement in each competency dimension.

The proposed programme combined the four 4T components across three successive stages. Basic focused on AI foundations and ethical responsibilities; Application emphasized supported planning, assessment tasks, practical problem-solving, and microteaching; and Development emphasized feedback, professional

collaboration, reflective adaptation, and ongoing growth. Three support levels were envisaged: individual teacher/classroom practice, school and peer professional communities, and specialist or technical assistance. Training Evaluation included diagnostic pre-testing, task-based appraisal, participant feedback, reflection, and post-testing. The report did not provide a complete session-by-session schedule or training dosage; accordingly, these descriptions outline the model's architecture rather than a fully replicable delivery manual.

Table 2. Summary of the four components of the 4T AI training model for primary school teachers in Yunnan Province.

Components	Key findings
Training Content	The training content should focus on AI literacy, technological knowledge, data literacy, ethical awareness, and practical application of AI tools in teaching and learning activities.
Training Methods	Interactive, collaborative, and practice-oriented learning approaches such as workshops, hands-on activities, collaborative learning, and problem-based learning should be emphasized.
Training Resources	Teachers should be provided with access to AI tools, digital platforms, instructional materials, technical support, and mentorship systems to support continuous learning and classroom implementation.
Training Evaluation	The evaluation process should include pre-test and post-test assessments, participant feedback, performance evaluation, reflective activities, and follow-up evaluation to assess both short-term and long-term outcomes.

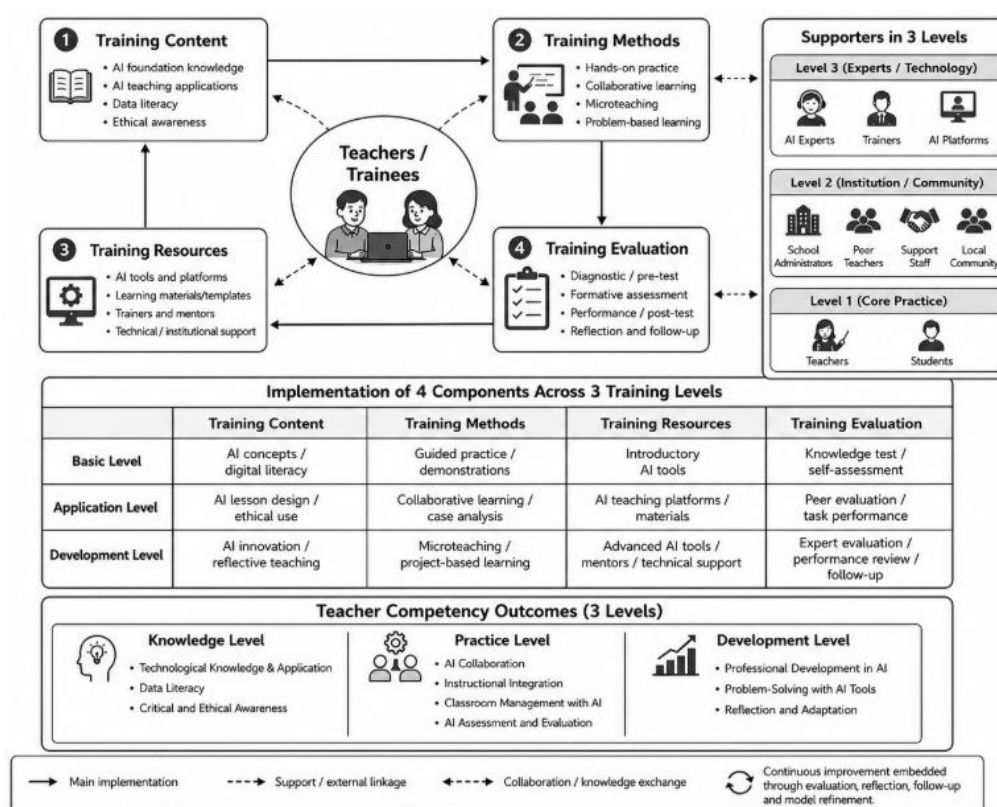


Figure 2. The 4T AI Training Model for primary school teachers in Yunnan Province.

Figure 2 depicts the proposed 4T AI Training Model and its implementation sequence. The eight planned activities are (1) review teacher readiness and needs, (2) introduce foundational AI knowledge, (3) provide guided AI-tool practice, (4) organize collaborative case activities, (5) conduct microteaching simulations, (6) provide resources and mentoring, (7) assess learning and performance, and (8) use feedback to refine subsequent practice. The model integrates Training Content, Training Methods, Training Resources, and Training Evaluation with staged learning and a three-level support structure. The ten competency dimensions describe intended outcomes; separate achievement changes for those domains were not established.

Results for Objective 3: Comparison of overall achievement scores before and immediately after preliminary training

Overall achievement scores increased from the reported

pre-test mean of 30.69 (SD = 1.64) to a post-test mean of 41.19 (SD = 2.95). The original paired-samples test result was $t(31) = 25.36$, $p < .001$, with a mean gain of 10.50 points on the 50-item test. To express the precision and standardized magnitude of the reported change, the original aggregate statistics imply a 95% confidence interval of approximately 9.66–11.34 points and Cohen's $d_z = t/\sqrt{32} = 4.48$. These supplementary measures are calculated from the previously reported summary statistics, rather than independently re-estimated from the individual scores.

The higher mean immediately after training is consistent with short-term improvement on the overall achievement test. Because the evaluation included only one group and an immediate post-test, the observed difference cannot be attributed exclusively to the 4T model; practice effects, concurrent learning, and other influences cannot be excluded. Domain-specific competency changes and classroom performance outcomes were not directly tested in this comparison.

Table 3. Comparison of artificial intelligence achievement-test scores before and after training ($n = 32$).

	$\bar{x}$	S.D.	t	p
Pre-test	30.69	1.64	25.36	< .001*
Post-test	41.19	2.95		

*Significant at the .001 level. M = mean; SD = standard deviation. Original test statistics retained.

DISCUSSION

Needs assessment of artificial intelligence skills among primary school teachers

The difference between teachers' current and desired AI competency ratings identifies perceived professional-development priorities in the Yunnan sample. Needs scores are self-reported ratings rather than performance measures, and thus should not be treated as definitive evidence of skill deficits. Nevertheless, the need for ethical decision-making and pedagogically appropriate application is consistent with human-centred teacher AI competence frameworks (Miao and Cukurova, 2024; Walter, 2024). Schools considering training should adapt foundational instruction and practical support to their local equipment, curriculum, and teaching demands.

AI Collaboration, Classroom Management with AI, Problem-Solving with AI Tools, AI Assessment and Evaluation, and Instructional Integration occupied the highest positions in the original PNI_modified ranking. Together they indicate that training priorities extend beyond operating tools to judgement, collaborative application, classroom organization, and assessment. The

specific order describes reported proportional gaps; it does not imply that differences between dimensions were tested for statistical significance.

Development of the 4T AI Training Model for enhancing artificial intelligence skills

The 4T AI Training Model connects the needs survey to four complementary activities: selecting Training Content, organizing Training Methods, ensuring Training Resources, and planning Training Evaluation. The Basic–Application–Development delivery stages describe a proposed progression from AI fundamentals to applied classroom work and reflective professional growth. This is compatible with, although not equivalent to, the staged logic of the UNESCO AI Competency Framework for Teachers (Miao and Cukurova, 2024). Specialist feedback offers preliminary evidence of practical relevance, not a controlled evaluation of alternative models.

Workshops, collaborative case activities, AI-assisted lesson design, microteaching, and reflection can help relate general technological knowledge to professional tasks. This emphasis is consistent with research on

teacher educators' AI literacy and the opportunities and challenges of generative AI in their professional learning (Prilop et al., 2025). Resource provision alone is insufficient without appropriate guidance, privacy safeguards, and opportunities for continuing feedback. Whether the proposed support structure can be implemented consistently across different schools requires further evaluation.

Effectiveness of the 4T AI Training Model for enhancing artificial intelligence skills

The reported overall achievement-test mean was higher immediately following training, and the reported paired-samples *t* statistic was statistically significant. This finding should be interpreted as an observed within-group score change, not as conclusive evidence that participation alone caused the improvement. Repeated testing, maturation, additional learning opportunities, and selection effects remain plausible explanations in the absence of a comparison group. The study did not evaluate gains separately for each competency dimension, longer-term knowledge retention, teaching observations, or pupil outcomes; corresponding claims cannot be inferred from the present results.

Limitations of the study

Several features limit interpretation of the findings. The Phase 3 cohort comprised only 32 teachers, with limited detail on recruitment and regional representation. The evaluation had no control group or random allocation, and the post-test was immediate, so persistence and transfer to classroom teaching are unknown. Numerical IOC and reliability coefficients, item-level achievement-test properties, training dosage, and formal ethics approval and consent details were not stated. The supplementary confidence interval and effect size are derived from originally reported aggregate test statistics; they do not replace independent examination of participant-level data. These constraints limit generalizability, causal inference, and replication.

CONCLUSION AND SUGGESTIONS

The needs assessment identified substantial differences between current and desired AI competencies among primary school teachers in Yunnan Province. The reported current-condition mean was 2.37 (*SD* = 0.65), the desired-condition mean was 3.99 (*SD* = 1.12), and the overall PNI_modified was 0.68. These descriptive results suggest priorities for context-sensitive professional development rather than providing direct performance assessments of the survey respondents.

The five highest-ranked needs were AI Collaboration (0.90), Classroom Management with AI (0.89), Problem-Solving with AI Tools (0.75), AI Assessment and Evaluation (0.75), and Instructional Integration (0.75). The 4T model translates these priorities into Training Content, Training Methods, Training Resources, and Training Evaluation, organized through Basic, Application, and Development stages with multi-level support. In the small one-group cohort, overall achievement-test scores were higher immediately after training, but sustained classroom benefits and causal effects remain unestablished.

Schools considering the model should supply approved tools, practical instruction, peer mentoring, technical assistance, and clear expectations for safe and ethical AI use. Future studies should document participant selection, programme duration, implementation fidelity, ethical oversight, and instrument properties, and should use suitable comparison groups, delayed assessments, and classroom observations. These additional measures are needed to determine whether short-term score changes translate into lasting improvements in teaching and learning.

New knowledge and the effects on society and communities

The principal contribution is an integrated, needs-informed 4T AI Training Model that links Training Content, Training Methods, Training Resources, and Training Evaluation with a staged process of teacher professional learning. In contrast to training that focuses only on software demonstrations, the proposed framework combines responsible AI use, technological and data literacy, instructional integration, classroom management, assessment, collaboration, and reflective improvement. The model may be a useful planning tool for schools seeking to connect AI fundamentals with classroom practice; its broader outcomes remain propositions for further evaluation, not measured effects.

For education providers and communities, the approach highlights the possible value of mentoring, peer collaboration, resource-sharing, and school-level support in widening access to relevant professional learning. These implications are particularly important for schools facing practical constraints, although this study did not directly measure reductions in school-level digital inequality or changes in student outcomes.

Ethical awareness is central to the proposed model, including protection of student data, recognition of algorithmic bias, and retention of teachers' professional judgement. The framework could be adapted for other school systems if curricular and resource conditions are carefully considered. Any future claims about improved classroom quality, teacher retention of skills, community benefit, or scalability should be evaluated using appropriately designed follow-up studies.

ACKNOWLEDGEMENT

The authors thank the primary school teachers and specialists whose participation informed the needs assessment, model development, and preliminary training evaluation. We also acknowledge the academic guidance received during preparation of this study.

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Citation: Meng, N., Sermsri, N., and Khamcharoen, N. (2026). Development of a training model for enhancing artificial intelligence skills of teachers in primary schools in Yunnan Province. *African Educational Research Journal*, 14(4), 888-895.
