

Exploration on the path of improving primary school teachers' Information Literacy under the background of artificial intelligence

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ABSTRACT To address superficial tool use and the disconnect between technology and pedagogy among primary school teachers, this study constructs a closed-loop improvement path of diagnosis, training, practice, and evaluation under the background of artificial intelligence. Based on a baseline survey, teachers are clustered into different levels of digital readiness, forming a precise profile for targeted professional development. "AI + subject" integrated courses are then designed according to subject-specific teaching pain points. Interdisciplinary lesson study communities are established to refine lesson plans through repeated cycles of topic selection, collective planning, classroom practice, and reconstruction. A human-machine collaborative reflection platform is further built to support classroom recording, personalized resource recommendation, online Q&A, and teaching reflection. Experimental results show that the average weekly use frequency of smart tools in the experimental group increases from 2.56 to 4.65 times. Lesson-plan scores of experimental teachers are significantly higher than those of the control group, and the ethical test pass rate increases from 40.0% to 80.0%. The study embeds information literacy improvement into real teaching scenarios and supports sustainable teacher development.

INDEX TERMS artificial intelligence, primary school teachers, information literacy, teacher development, human-machine collaboration

I. INTRODUCTION

ARTIFICIAL intelligence technology is gradually transforming the basic education environment by repatterning traditional pedagogical structures with the precision. This digital integration functions as a high-tech loom, interlacing intelligent data analytics into the very fibers of classroom interaction to create a more resilient and versatile educational fabric. Intelligent lesson preparation software, learning analysis software, generative artificial intelligence have gradually appeared in primary school classrooms [1,2]. But the current primary school teachers' information literacy upgrading faces the following three dilemmas: First, the application of intelligent tools is superficial. Primary school teachers only use PPT presentations or video playback, but do not use the accurate diagnosis and personalized guidance functions of artificial intelligence; Second, data literacy is weak. Primary school teachers generally cannot analyze classroom data and cannot convert data analysis into teaching decisions; Third, the problem of teaching and technology "two separate" exists. The traditional training emphasizes the operation of the software, but ignores the integration of teaching subjects [3,4]. These problems cause

teachers to become "masters of the tool but not aware when and why to use the tool", forming "technology silos", which cannot meet the deep needs of intelligent education for teacher's quality.

Regarding the improvement of teachers' information literacy in the era of artificial intelligence, existing research mainly focuses on the construction of training curriculum systems and the cultivation of technical application capabilities. Trapitsyn and TURSUNBAEVA pointed out that the traditional teacher information literacy training centered on computer skills is insufficient and should incorporate new capabilities for understanding and evaluating intelligent systems to serve teacher training and the digital transformation of education [5]. Zhang et al. investigated the opportunities, difficulties and impacts of integrating artificial intelligence into teacher education, pointing out that it can support classroom management, promote inclusive and personalized teaching and enhance digital competence, but it is necessary to overcome related integration barriers [6]. Tella examined the traditional practices and content update needs of information literacy teaching in Nigerian universities, sorted out the advanced technologies that can

be used for teaching and the challenges they bring, and proposed the modernization direction of academic library information literacy teaching in the face of the Fourth Industrial Revolution [7]. In response to the problem of insufficient connection between educational artificial intelligence research and teaching perspectives, Chiu et al. used the autonomy theory as a framework to examine how teacher support can regulate the impact of students' professional knowledge on demand satisfaction and intrinsic motivation for learning with artificial intelligence [8]. Filgueiras discussed the reshaping effects of artificial intelligence and big data on education, teaching, curriculum and management and education policy governance, while examining its risks and limitations, and analyzed the institutional challenges of digital new governance practices and their potential impact on social justice from the perspective of the Beijing Consensus [9]. Fitria et al. explored the role and application of artificial intelligence in English teaching through literature research, believing that it can create a good and personalized learning atmosphere, enabling learners to comprehensively train English skills according to their own level, needs and interests [10]. While established frameworks by Zhang et al. and Chiu et al. address general AI support and motivation, they often treat AI as an external auxiliary tool rather than a collaborative partner in the instructional design process. This study moves beyond 'AI-as-tool' by proposing a 'four-dimensional linkage' that specifically targets the synchronous co-evolution of teacher pedagogy and machine intelligence within a closed-loop 'diagnosis-training-practice-evaluation' cycle, ensuring that human-computer collaboration is embedded into the structural logic of daily lesson planning rather than remaining a peripheral technical add-on.

To overcome these deficiencies, this paper adopts quasi-experimental research method, takes "four-dimensional linkage" closed loop of "diagnosis-training-practice-evaluation" into deep connection of daily teaching context with teacher information literacy improvement to solve problem of technology and teaching detached, and explores path of improving primary school teachers' information literacy in artificial intelligence background. Quasi experimental research design was adopted in this study. Two primary schools with similar scale were selected as experimental subject. Experimental group (45 teachers) received "four-dimensional linkage" training, while control group (42 teachers) received routine training. By precisely profiling teachers' initial digital competencies across the dimensions of technical proficiency, pedagogical content knowledge, and data interpretation skills, we can design 'AI + Subject' courses that empower educators to leverage intelligent tools for personalized instruction and automated assessment. This ensures that the training aligns with the specific digital literacy levels and subject-specific pain points of primary school educators.

II. BASELINE SURVEY OF TEACHERS' INFORMATION LITERACY

In order to have a clear understanding of the current situation and differences of teachers' information literacy level, the baseline survey was carried out prior to the training. The questionnaire includes the questions about the level of cognitive about intelligent technology, the usage of intelligent tools in regular teaching, and the understanding of data privacy protection, etc. Totally 87 questionnaires were randomly dispatched and 87 valid questionnaires were collected. In addition, the researchers randomly observed the two regular classes taught by the teachers and recorded the details of using interactive smart whiteboard and student feedback software.

Based on the survey data, a K-means cluster analysis algorithm was employed, using standardized scores of technical self-efficacy, tool usage frequency, and data ethics awareness as clustering variables. Through iterative testing, the optimal number of clusters was determined to be three, effectively partitioning the teachers into distinct profiles based on their digital readiness: First, "technology-fearing" teachers, accounting for approximately 32%, who held a wait-and-see attitude towards intelligent tools, rarely using them proactively in the classroom, and worried that technical errors would affect the teaching pace; second, "experience-dependent" teachers, accounting for approximately 45%, who habitually used traditional teaching methods, only occasionally using intelligent tools in public classes or during inspections, lacking continuity and depth in application; and third, "tool-experience-seeking" teachers, accounting for approximately 23%, who had high enthusiasm for new technologies, but whose use was mostly limited to functional exploration, lacking organic integration with subject teaching, and had a vague understanding of data ethics issues.

III. DESIGNING AI + SUBJECT-SPECIFIC INTEGRATED TRAINING COURSE

Taking Chinese as an example, the training team identified the pain point of spending a lot of time correcting students' essays and being unable to provide timely feedback to students, and then introduced an AI-based intelligent essay evaluation system. First, the teachers observed how the system completed the initial evaluation of all the class's essays within five minutes and produced visual reports of such indicators as language fluency and coherence. Then, under the guidance of an expert, the teachers compared the scores given by the system and human beings, and discussed how to use the data from the system for effective feedback. In the mathematics lesson, they focused on the pain point of being unable to analyze student learning, and encouraged teachers to use an intelligent diagnostic platform to collect real-time data of classroom practice. By analyzing the knowledge graph produced by the system, teachers could quickly find common weak points for the whole class and individual errors for quick correction. In science, training transitioned from simple virtual simulation operation to

data-driven experimental analysis, where teachers learned to interpret error distribution patterns in simulated results to diagnose students' conceptual misconceptions. Similarly, the English module moved beyond voice assessment tools to focus on analyzing longitudinal pronunciation data and using automated fluency metrics to make informed decisions about personalized oral interventions.

Each subject training includes three parts: First, the subject teaching researchers explain typical long-standing problems existing in the teaching of the subject, creating a cognitive conflict for teachers; then the technology experts demonstrate the core functions and usage of the corresponding intelligent tools; finally, the experienced teachers demonstrate the integrated lesson examples. The participating teachers are grouped and asked to design "same lesson, different approaches". This design ensures that teachers always have subject-related questions in their minds when learning technology, and that the technology is used to solve their pain points in teaching, rather than becoming a burden.

One teacher in the Chinese language group recorded in their training notes: "I used to think that artificial intelligence was far removed from the Chinese language classroom. But now that I've seen how it graded fifty essays within five minutes, I think that technology can really release my energy from mechanical labor and enable me to focus on students' thinking development." In addition, based on the subject training, every month, teachers from different subjects organize an interdisciplinary workshop to conduct project-based learning design based on the same theme (such as "spring" or "hometown") and explore how artificial intelligence can be used in interdisciplinary teaching.

IV. ESTABLISHING INTERDISCIPLINARY LESSON STUDY COMMUNITIES

Both communities are founded on the model of "backbone leadership, interdisciplinary blending and voluntary engagement". In each community, there are 6 to 8 teachers from different subjects such as Chinese, mathematics, science etc. and at least one of them is core information technology teacher as well as subject leader. There were in total 10 interdisciplinary communities established in this school. All 45 teachers involved in the experimental group were engaged in the communities. Each community has an university expert or district education researcher as academic advisor assigned to guide the experimental community through the lesson study process in each stage.

Lesson study refinement moves in a cyclical fashion through the following four stages: "topic selection - collective lesson planning - classroom practice - debriefing and reconstruction". The first stage is topic selection. Community members, guided by the school teaching progress, settle on a target unit content for interdisciplinary integration. In the example of the fifth-grade unit "The Movement of Shapes", the mathematics teacher teaches axially symmetric figures, the art teacher guides students to express the

beauty of symmetry by paper cutting, and the information technology teacher provides Geometer's Sketchpad software to enable students to dynamically simulate the motion and transformation of shapes. Artificial intelligence technology is applied to model students' operational trajectory and assess students' spatial reasoning development.

The second stage is collective lesson planning. Members collaboratively discussed how to embed intelligent tools into their respective subjects and designed connecting elements. The lesson preparation process emphasized "three preparations": first, preparing teaching objectives, clarifying the core competencies of each subject in this unit; second, preparing for technology integration, discussing the best timing and methods for introducing intelligent tools—whether to use AI-assisted diagnosis or expand learning resources; and third, preparing collaborative nodes, determining which links require multidisciplinary collaboration to ensure students can establish interdisciplinary connections. The lesson preparation outcome was a detailed integrated lesson plan, marking the intention of technology use and data collection points for each lesson. The third stage was classroom practice. Each member taught in their own class in turn, while other members observed and recorded the entire lesson. Observation dimensions included the fluency of technology use, the depth of student interaction with intelligent tools, and the utilization of classroom-generated data. Classroom recordings were simultaneously uploaded to the school-based professional development platform for later review. For example, in a math class, the teacher used the smart classroom system to collect student drawing data in real time; the system automatically generated an error type distribution chart, which the teacher used for precise feedback. Observing teachers focused on the teacher's response strategies after system prompts, recording whether the teacher effectively used data to adjust teaching.

Immediately after the lesson, the community holds a seminar. First, the teacher who taught the lesson speaks, sharing the experience of reflection on gains and losses in using the technology. Then observing teachers feed back to him/her based on the observation data, commenting on what technological elements have promoted learning and what technological elements have interfered with learning, and jointly developing a plan for improvement, which the next teacher will try. Usually the same lesson will go through three or even more rounds of "practice-debriefing-reconstruction" until a relatively mature integrated paradigm is developed. In "the movement of shapes", in the first round of the math lesson, it was found that students spent too much time using Geometer's Sketchpad, squeezing out time for concept understanding. So in the second round, students were asked to practice using micro-lessons before class, and to focus on exploring the core concepts during class. In the third round, they even introduced artificial intelligence to analyze the types of errors committed by students in their work, so as to facilitate differentiated instruction.

V. BUILDING A HUMAN-MACHINE COLLABORATIVE REFLECTIVE SUPPORT PLATFORM

According to the record-reflection-support-improvement logic. Each teacher owns a personal space and the teacher's teaching video in classroom will be automatically pushed from classroom recording system and the technology usage behavior information in smart classroom observation system will be recorded. The system will also collect attendance, assignment and discussion information of each professional development activity. Finally, these information will be summarized into digital professional development profile for each teacher. The teacher can replay their teaching video anytime and conduct self-reflection according to the improvement goal set at the beginning of professional development. The improvement goal will be set at the beginning of professional development.

For resource support, we designed a dynamic push mechanism. According to teacher's ability type during precise profiling stage and behavioral data during subsequent professional development, system will push corresponding personalized learning resources to teachers in school every week. For teachers exhibiting technology-averse profiles, the system pushes basic operation micro-lessons and foundational case studies; for teachers with high technology-dependency, it provides advanced integrated pedagogical paradigms; and for early-adopter teachers focused on functional exploration, the system prioritizes cutting-edge updates and specialized modules on data ethics. The resource library is maintained by teaching and research group and maintained by technical team. The system will push resource library every week to ensure the timely update. Interactive support is the most important function of our platform. We established an "AI-Assisted Teaching Q&A" section. A Q&A team consisting of university experts, regional teaching and research staff and technical backbone personnel will take turn to online. Teachers can post questions in the fixed section anytime. When teachers met with technical problems in teaching or design issue in daily teaching, they can post question in the section and get answer within half day. In addition, the section is not only for answering questions, but also a forum for teachers to exchange experiences. For example, when a teacher posted a question about when to introduce intelligent diagnostics in lesson preparation, several colleagues shared their experiences after posting. Finally, all colleagues reached an operational framework of "pre-lesson pre-diagnosis – in-lesson follow-up – post-lesson confirmation". Both colleague support and expert support reduce the loneliness of teachers working alone.

The application also has a reflection and check-in function. Every week, teachers need to submit a brief teaching reflection (it could be a short text, a screenshot of classroom data, or a short video file) for the platform, describing their attempts and experiences in human-computer collaborative teaching. The reflection would automatically become part of their personal growth portfolio and would serve as the basis for all of the subsequent professional development

credits. At first, most of the teachers saw the check-in as their duty, and their reflections were just formalities. With time, however, more and more teachers started to reflect sincerely. A math teacher reflected as follows: "Today, I tried to use the intelligent system to collect students' answers quickly and found that the accuracy was much lower than I expected. I immediately adjusted the teaching pace, and the effect was quite good. Before, I always stuck to the lesson plan; now I dare to adjust according to the data, which is a change." This kind of reflection based on the collection of data information is a sign that information literacy is gradually becoming internalized. Table 1 shows examples of various statistical data after the platform has been running for a semester.

VI. MULTIDIMENSIONAL EVALUATION SYSTEM FOR THE EFFECTIVENESS OF THE PATHWAY

A. EXPERIMENTAL SETUP

To systematically verify the actual effect of the "Four-Dimensional Linkage" implementation path, this study adopted a quasi-experimental design, selecting two primary schools in a district with similar school size and teacher qualifications as research subjects. One school served as the experimental group (all teachers participated in the complete training path), and the other served as the control group (receiving only routine information technology training). The experimental period was one semester. Data was collected from three dimensions—teachers' use of intelligent tools, their innovative teaching design ability, and their level of data ethics awareness—through pre- and post-test comparisons. These corresponded to three sub-experiments: a comparative experiment on the penetration rate of intelligent tool applications (statistics of weekly usage frequency through the classroom observation system), a comparative experiment on the rating of human-computer collaborative lesson plans (blind review and scoring by district teaching and research staff based on an innovation scale), and a comparative experiment on the pass rate of data ethics knowledge tests (calculation of the pass rate through a closed-book examination). All data were statistically analyzed using independent samples t-tests, chi-square tests, and analysis of covariance to comprehensively evaluate the path's promoting effect on teachers' information literacy.

B. COMPARATIVE EXPERIMENT ON THE PENETRATION RATE OF SMART TOOLS IN REGULAR CLASSROOMS

The two primary schools that were chosen as experimental subjects in this study were similar. The experimental (45 teachers) and control group (42 teachers) were subjected to the Four-Dimensional Linkage professional development program and standard training respectively. One semester was the period of the experiment. The measurement indicator was the frequency with which each teacher used smart tools during the five teaching days in a row, and the mean frequency during the week was determined using a smart classroom monitoring system.

TABLE 1. Operational data of human-machine collaborative reflective support platform

Item	Quantity	Description
Teacher Personal Space	45	All experimental group teachers
Classroom Recordings	680 lessons	15.1 per teacher
Intelligent Analysis Reports	360 reports	Bi-weekly
Personalized Resources	1,350 items	1.5 per teacher/week
Q&A Forum Interactions	468 posts	Avg. response 3.2h
Teacher Reflection Journals	2,146 entries	47.7 per teacher
Resource Library Downloads	3,150 times	Micro-lessons, cases, etc.

Figure 1 shows that after one semester of “Four-Dimensional Linkage” professional development, the average weekly usage frequency of smart tools by teachers in the experimental group significantly increased from 2.56 times to 4.65 times ($p < 0.001$), while the control group only slightly increased from 2.54 times to 2.88 times ($p = 0.136$). The difference between the two groups was significant in the post-test ($p < 0.001$), with the experimental group exceeding the control group by 1.77 times/week. This indicates that this approach effectively addresses the problem of teachers “knowing how to use it but not using it frequently,” significantly enhancing the penetration rate of intelligent tools in regular teaching and laying a solid behavioral foundation for teaching innovation.

C. COMPARATIVE EXPERIMENT ON THE RATING OF HUMAN-MACHINE COLLABORATIVE LESSON PLANS IN REGIONAL TEACHING RESEARCH

In the mid-term of the experiment, the teachers in the experimental group and control group completed the human-machine collaborative lesson plan for the teaching content of the same unit. The plan should explain the use, construction and expected effects of artificial intelligence tools. Finally, three teaching researchers at the district level carried out the blind review and scored the lesson plans according to the Evaluation Scale for the Innovation of Human-Machine Collaborative Lesson Plans. A score of 5 points (Excellent) required technology to be a ‘seamless catalyst’ that enables otherwise impossible pedagogical tasks, while 1 point (Poor) indicated technology was a ‘superficial add-on’ with no impact on learning logic. Intermediate scores were assigned based on the degree of alignment between digital tools and specific subject-matter pain points. The average score of the three scores was the final score. The detailed results were shown in Table 2:

TABLE 2. Comparison of Rating Results of Human-Computer Collaborative Lesson Plans in Regional Teaching Research

Group	N	Mean Score	Std Dev	t-value	p-value
Experimental	45	16.2	1.8	8.94	< 0.001
Control	42	12.5	2.1		

The experimental group teachers’ average score for human-computer collaborative lesson plans was 16.2, significantly higher than the control group’s 12.5 ($t=8.94$, $p < 0.001$). Specifically, the experimental group excelled in technology integration and personalized support, effectively embedding intelligent tools to assist differentiated instruction in their lesson plans. In contrast, most lesson plans in the control group remained within traditional frameworks, simply adding technological elements. This indicates that the “four-dimensional linkage” training effectively enhanced teachers’ ability to deeply integrate artificial intelligence with subject teaching, enabling them to produce more innovative and effective teaching solutions.

D. COMPARATIVE EXPERIMENT ON THE PASS RATE OF TEACHERS’ DATA ETHICS KNOWLEDGE TEST

Two groups of teachers took a standardized closed-book test before and after the experiment. The test paper was designed by educational technology experts and included 20 multiple-choice questions on protecting data privacy, identifying biases in algorithms, and the limits of using artificial intelligence. The score was out of 100 points, with 60 points or above considered passing. The purpose of the test was to evaluate the teachers’

ethical awareness and knowledge of ethical guidelines regarding the use of artificial intelligence. Details are presented in Table 3:

TABLE 3. Comparative Evaluation of Teachers’ Data Ethics Knowledge Test Pass Rate

		χ^2 value		p-value	
				< 0.001	
Group	Time Point	Number Passed	Total Number	Pass Rate	
Experimental	Pre-test	18	45	0.4	14.52
	Post-test	36	45	0.8	
Control	Pre-test	17	42	0.405	0.21
	Post-test	19	42	0.452	

The pass rate of the teachers' data ethics knowledge test in the experimental group significantly increased from 40.0% in the pre-test to 80.0% in the post-test ($\chi^2 = 14.52$, $p < 0.001$), while the pass rate in the control group only slightly increased from 40.5% to 45.2% ($\chi^2 = 0.21$, $p = 0.647$). The post-test pass rate differed significantly between the two groups ($\chi^2 = 11.23$, $p < 0.001$), with the experimental group scoring 34.8 percentage points higher than the control group. The results indicate that the "four-dimensional linkage" training effectively strengthened teachers' ethical awareness in human-computer collaborative teaching, enabling them to process student data more effectively and identify algorithmic biases, thus providing cognitive assurance for the safe application of artificial intelligence in primary school education.

VII. CONCLUSION

This paper demonstrates that the "diagnosis-training-practice-evaluation" four-in-one path successfully enhances the information literacy of educators by integrating material informatics and intelligent weaving simulations into their pedagogical toolkit. This framework empowers teachers to bridge the gap between digital literacy and modern manufacturing processes, fostering a specialized capability to guide students through the complexities of smart fiber technologies and data-driven industrial design. This road, both directly, through refined diagnosis of teachers to identify their skill shortcomings, and indirectly, through project-based training, using real life examples of a lesson, not only addresses the issue of the discontinuity between the traditional training and teaching context, but also facilitates the growth of the teachers professionally on three fronts; technology application, instructional design and ethical awareness. Experimental group teachers were much better than the control group in frequency of intelligent tool use, quality of human-computer collaborative lesson plans and pass rate in data ethics knowledge tests which confirmed systematic nature and effectiveness of the path. This research has shortcomings: the sample was limited to two schools within the same area and was not representative enough; the experimental process lasted just a semester, and the outcomes should also be monitored in the long term. Future studies will expand the sample size and longitudinal tracking to investigate how teacher information literacy directly influences student learning outcomes within the specialized domain of high-performance fiber science and chemistry. By incorporating smart assessment instruments, the research will achieve precise profiling and dynamic feedback to ensure teacher development aligns with the evolving digital demands of

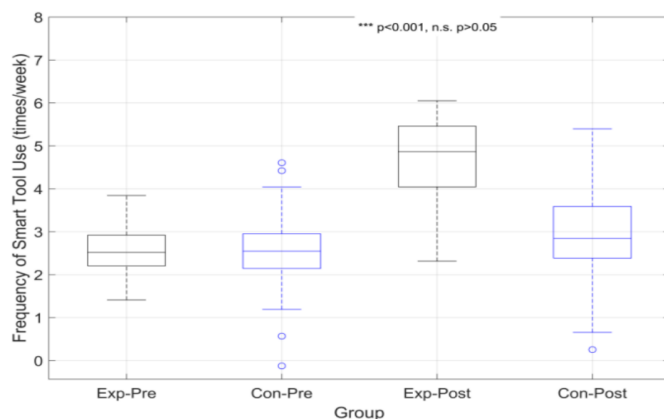


FIGURE 1. Comparison of the Penetration Rate of Smart Tools in Regular Classrooms

automated spinning and technical production.

AUTHOR CONTRIBUTIONS

Hongyan Cao designed, collected and analyzed the data, and drafted the manuscript. Hongyan Cao conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Hongyan Cao participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

FUNDING

This research received no external funding.

ACKNOWLEDGEMENTS

Not applicable.

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