Artificial Intelligence – Driven Innovation Mechanisms for Developing Digital Literacy in Higher Education Teachers

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ABSTRACT This study explores artificial intelligence-driven innovation mechanisms for developing digital literacy among higher education teachers. By constructing personalized learning pathways and an intelligent intervention model, a 12-week experimental study is conducted to compare digital literacy changes between an experimental group and a control group. The model evaluates teachers' digital literacy through multiple dimensions, including digital cognition, technical application, human-AI collaboration, and digital ethics, and uses AI-supported diagnosis, recommendation, task training, and feedback iteration to support differentiated development. The results show that teachers in the experimental group significantly outperform those in the control group in overall digital literacy, multidimensional improvement, and learning-pathway alignment. Gains in digital cognition and human-AI collaboration are particularly pronounced. The experimental group achieves a 20.2-point increase in digital literacy, while the control group increases by 6.0 points, confirming the advantages of the AI-empowered approach. This study provides a theoretical framework and practical pathway for cultivating teachers' digital literacy in higher education under educational digital transformation.

INDEX TERMS artificial intelligence, digital literacy, personalized learning, teacher development, human-ai collaboration

I. INTRODUCTION

GIVEN that the ongoing digital transformation of education has fundamentally reshaped pedagogical landscapes, the significant development of teachers' digital literacy could indicate a critical foundation for improving the important educational quality and for fostering innovation. Moreover, artificial intelligence, as a transformative technology, may increasingly integrate into educational contexts and might offer new approaches for enhancing teachers' digital literacy. However, existing research has largely focused on conceptual discussions or macro-level strategies, with limited mechanism-based modeling and empirical validation, particularly in higher education contexts. In light of these important gaps in the literature, this study might focus on higher education teachers and could examine the mechanisms through which artificial intelligence supports digital literacy development. The study aims to: (1) construct a quantifiable multidimensional model of teachers' digital literacy; (2) design AI-centered personalized learning pathways and intelligent interventions; and (3) validate effectiveness of the AI-empowered approach through a controlled experiment. Nevertheless, this research may provide mechanism-oriented theoretical explanation and practical pathway for cultivating digital literacy among higher education teachers in the context of educational digital transformation.

II. THEORETICAL FOUNDATION AND RELATED RESEARCH

A. THE CONNOTATION AND STRUCTURAL MODEL OF TEACHERS' DIGITAL LITERACY

The level of facility with various forms of technology that individuals who provide instruction demonstrate represents an important element within the larger structure of capabilities required for their work in the current period, when forms of instruction increasingly involve technology. The meaning of this concept has shown change over time, developing from an initial focus on specific skills relating to technology to a more complete structure that includes awareness, capability, and responsibility. Wang and Dai, in work examining the development of this facility among individuals providing instruction in the UK, indicated that efforts to increase this facility should occur within the larger structure of national efforts relating to technology in instruction, using design that combines different elements in setting standards, developing capability over time, and assessing capability, which allows development that moves from providing resources to initiatives that involve larger systems [1]. Jin et. al using

research that examines data from a large sample, found that the level of facility with technology that individuals providing instruction demonstrate shows a relationship with their capability for using technology in instruction and also affects this capability through acceptance of technology and the ability to respond to challenges, which indicates that this facility includes multiple aspects relating to cognition, attitude, and behavior [2].

Regarding models of structure, Li presented a structure with four main forms—including technical skill, professional skill, the capacity to provide nurturing, and capacity for leadership—that shows the range and developing nature of digital skills for teachers in the era using systems that process information in ways similar to human thinking [3]. Zhou and other individuals provided further support for the changing nature of these skills across five years, and this work revealed the process operates through multiple levels that reflect differences between individuals, differences across areas, and differences over time [4]. Zhu and Li examined this issue from the view of strategy for making education more digital and from the view of using systems that process information, and these individuals indicated that digital skills for teachers should include new elements that involve ethics in digital contexts, skills for using systems that process information, and working together with machines, and these elements provide the basis for developing a model that fits the current era [5,6].

B. THEORETICAL FOUNDATION OF AI-DRIVEN EDUCATION

The foundation in theory for education using these systems follows from examining how technology develops, how individuals work with machines, and how values in education change over time. Zhang presents a view with five parts that describe how teachers develop knowledge when using systems that generate content, indicating that these systems moved from simple tools to elements that extend how teachers think, and this change supports ongoing development of teaching knowledge through work combining human and machine approaches [7]. Sun and Zhang examine large models such as DeepSeek and reveal that values from Eastern philosophy appear in how designers create these technologies and apply them in education, and the analysis shows movement from making technology available to making education possible in different forms [8]. Wu, An, and Zhang use ideas from functionalism to establish what these systems can and cannot do in education, and they suggest that collaboration between humans and machines provides a means to maintain the main role of education [9]. Zulfiqar and others conduct research using data from the TAM and TPB models that show these systems affect how students approach learning through factors relating to usefulness that individuals perceive and how simple the systems appear to use, and these findings provide support from theory and examples from other countries for using these systems to strengthen education at higher levels [10].

C. CURRENT RESEARCH ON TEACHERS' DIGITAL LITERACY CULTIVATION

Research examining approaches to developing digital literacy in teachers shows work from different perspectives. Studies investigate targets for this development, paths that support it, and frameworks that provide theory. Thapa and Bankira use data from participants to show that levels of digital literacy appear moderate in general but differ significantly between different subject areas. These findings suggest that approaches to developing digital literacy require differentiation to address variation across disciplines [11]. Xu and Li apply a framework combining technology, subject knowledge, and teaching practice to examine current efforts in this area. The analysis reveals that these efforts show limitations in several aspects. Integration of technology with subject-specific knowledge appears insufficient, abilities relating to practical application remain limited, and collaboration within professional groups occurs infrequently [12]. Zeng examines factors that present obstacles to improving digital literacy among teachers from the perspective of national strategy. This work identifies main barriers that include concepts about technology and teaching that appear outdated, systems for supporting development that remain incomplete, and resources for this development that show insufficiency [13].

Studies examining approaches across different settings show various perspectives. Zou used a framework describing information systems to describe the approach for developing digital capacities in teachers at vocational institutions in the European Union, indicating that coordination between environmental factors, resources, and technological elements is important [14]. Lin and Liu examined game-based theories and suggested that using game elements in teaching can develop teachers' digital understanding and teaching abilities [15]. Bai and colleagues used an ecological framework and found that general training approaches and closed systems limit the development of digital capacities in teachers working in vocational education [16]. Luo compared approaches across different settings and indicated that using standards for guidance, conducting precise assessment, and establishing digital networks are major patterns in developing teacher digital capacities [17]. Studies to this point have provided significant contributions regarding fundamental ideas and approaches, but work examining mechanisms relating to artificial intelligence systems and precise support methods shows limitations.

D. THEORETICAL POSITIONING AND INNOVATIVE MECHANISMS OF THIS STUDY

Current research provides important work on developing digital abilities of individuals who teach by examining meanings, approaches for development, and support from organizations. However, the work in this area shows particular limitations. Most studies present definitions and describe experiences that appear in practice. The approaches that these studies suggest show similar features across different

contexts and the methods that control development appear general in nature. Work in this area also indicates that technology provides tools but this view limits the role that technology can occupy in the process. Most important, research lacks models that describe mechanisms and lacks data that provide evidence of effects in contexts that use artificial intelligence. This study examines development of digital abilities in a context that combines educational approaches using digital methods and artificial intelligence. The work uses models that describe the structure of digital abilities, cooperation between individuals and machines, and acceptance of technology by individuals. The study treats digital abilities as a system that allows measurement, shows development over time, and permits intervention.

The work presents a mechanism that uses artificial intelligence in a process that includes evaluation, identification of issues, intervention, and response. This mechanism positions artificial intelligence not as a tool that assists but as a factor that affects outcomes in the development process. The approach shows particular features in different areas. The first area involves creating detailed descriptions and ongoing evaluation of digital abilities using a model that examines multiple dimensions. The second area uses methods based on algorithms that produce learning approaches for individuals and plans for intervention that differ across cases. This addresses limitations that appear in approaches that provide the same development for all individuals. The third area implements methods that use data to provide response that improves outcomes. This allows the process to show ongoing changes and improvements that respond to conditions. This position in theory and this mechanism provide an approach that uses artificial intelligence for developing digital abilities of individuals who teach in settings of higher education. The approach allows replication across contexts, permits verification using data, and shows potential for extension to other settings.

III. AI-DRIVEN MECHANISM FOR DEVELOPING TEACHERS' DIGITAL LITERACY

A. CONSTRUCTION OF A MULTI-DIMENSIONAL EVALUATION MODEL FOR TEACHERS' DIGITAL LITERACY

To provide precise and measurable development of digital literacy using means that involve AI, the study presents a model for evaluation that includes multiple dimensions and structure. Using research on digital literacy and required capabilities in the AI era, this work describes digital literacy as a space with multiple dimensions that include the cognitive dimension, the capability dimension, and the responsibility dimension. The cognitive dimension examines understanding of digital technology, AI principles, and the value that educational digitalization provides. The capability dimension considers practical skills in using digital tools, teaching that uses data, and collaboration between humans and machines. The responsibility dimension reflects awareness of digital ethics, data security, and technology governance. The model creates an evaluation system that includes indicator levels, dimension levels, and overall levels, and this system applies weight distribution and methods for standardization. This approach allows quantification and dynamic description of digital literacy, and it provides foundational data for diagnostics using AI and interventions that follow, and the framework appears in Figure 1.

B. OVERALL FRAMEWORK FOR AI-DRIVEN DIGITAL LITERACY DEVELOPMENT

The study presents a framework that supports development of abilities in using technology for individuals working in education. This framework follows a particular approach. The approach uses data to provide support and uses that data to suggest actions and adjust actions over time. The system uses data from assessment of abilities and data from actions that individuals in education show. The system applies methods that allow identification of features in that data and identification of current states and identification of areas that require development. The system uses models in the middle part of the framework. These models provide suggestions and these models indicate likely patterns in development of abilities over time. The framework provides plans in the output part. These plans differ for different individuals and these plans reflect particular features that individuals show. The framework shows collaboration between technology and individuals. Technology provides support for work that requires large amounts of calculation and technology identifies patterns in data and technology suggests approaches that appear most effective. Individuals working in education and individuals that provide oversight for education focus on different work. This work includes setting objectives and this work includes making decisions that reflect values and this work includes adjusting approaches to reflect particular conditions in different settings. The framework combines approaches that technology provides with approaches that education requires.

C. PERSONALIZED LEARNING PATHS AND INTELLIGENT INTERVENTION MECHANISMS

The main element in development that uses digital means to develop understanding for teachers involves learning designs that differ for teachers. These designs that differ across teachers use analysis that combines suggestions with rules to produce paths that show differences.

The implementation level organizes AI-recommended learning content into four modules that may provide comprehensive coverage. Moreover, the first module addresses digital cognition, which encompasses basic AI principles, educational digitalization policies, and representative applications that appear relevant to foundational understanding. The second module focuses on technology application, covering instructional platforms, data-driven teaching tools, and intelligent support systems. Furthermore, the third module examines human–AI collaboration, including AI-assisted instructional design, collaborative tasks, and scenario-based

simulations. The fourth module addresses digital ethics, covering data security, algorithmic bias, and educational responsibility.

However, clear distinctions between experimental and control groups could enhance reproducibility. The experimental group follows a four-step process in each stage—diagnostic assessment, pathway recommendation, task-based training, and feedback iteration. Given that teacher profiles provide critical information, the system recommends 3–5 micro-learning units and two practice tasks. Nevertheless, the system adaptively adjusts content and task difficulty using behavioral data and stage assessments. In contrast, the control group receives uniform training with fixed content, schedule, and non-adaptive feedback. Moreover, the AI system may analyze teachers' current proficiency, developmental constraints, and learning preferences. Thus, the system dynamically matches content and triggers interventions. This approach enables a shift from uniform training to precision-oriented capability development.

D. FEEDBACK OPTIMIZATION MECHANISM FOR DIGITAL LITERACY IMPROVEMENT

The study provides a mechanism for improving training using data and forming a system that allows for continuous regulation. The system collects data on learning behaviors, on completion of tasks, and on assessments that occur at different stages in the training process. This data collection occurs in real time. The mechanism uses models that provide feedback to evaluate outcomes from the training. The evaluation compares these outcomes with results from the initial diagnostic process. The system uses this feedback to adjust parameters that determine the learning path and strategies for intervention. These adjustments occur in a manner that allows the system to adapt and to improve the training plan. The mechanism also allows for tracking of development in digital literacy across time for teachers who participate in the training. This tracking provides support for decisions that management requires. The feedback mechanism changes the approach to development of digital literacy from a single intervention to a process that continues over time and that involves repeated cycles of improvement. This change increases the degree to which the model that uses artificial intelligence to provide empowerment shows stability and shows capacity for expansion to different contexts.

IV. RESEARCH METHODS AND SIMULATION DESIGN

A. EXPERIMENTAL SUBJECTS AND SAMPLE GROUPING

The study included teachers in service from a comprehensive university as individuals in the sample. The approach used sampling by groups and assignment to groups, and the sample contained 120 teachers in total. The sample focused on different departments, and these teachers showed experience from 3 to 25 years, which indicates the range of capabilities with technology in the population of teachers in higher education.

Before the study, an initial measure of capabilities with

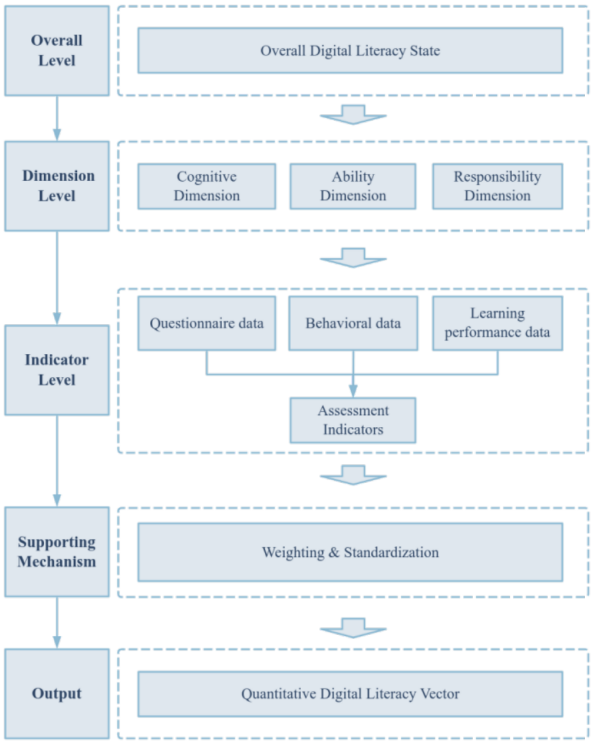

FIGURE 1. Multidimensional Evaluation Framework of Teachers' Digital Literacy

technology occurred for teachers, and the approach matched individuals by initial measure results, area of teaching, and years of experience. Teachers' AI readiness could indicate that potential confounding variables may well require significant methodological control in the experimental design, given that technological cognition, usage intention, and substantial self-efficacy dimensions were assessed through the scale alongside workload quantification. Moreover, the workload measures may suggest that self-reported weekly teaching hours, research tasks, and administrative responsibilities provide relevant operational indicators. Workload was quantified based on self-reported weekly teaching hours, research tasks, and administrative responsibilities. However, baseline equivalence testing might show no significant differences between groups on these variables ($P > 0.05$). Therefore, internal validity of results may be strengthened.

The sample then followed assignment to a group that received treatment (n = 60) and a group that provided comparison (n = 60). The group that received treatment used a model for developing capabilities with technology that involves systems providing responses, and the group that provided comparison received training that follows standard approaches.

The study occurred over 12 weeks, and this period divided into four separate stages, with 3 weeks for each stage. At the end of each stage, both groups received assessment, and data on behaviors in the study were collected for analysis across time. The sample total, the structure of groups, and the period of the study were controlled to provide significance in analysis and allow comparison of the results.

B. TEACHERS' DIGITAL LITERACY EVALUATION METHOD

Teachers' digital literacy was quantified using a multidimensional evaluation model. Let the standardized score of teacher i in the k-th dimension be x_{ik}, with corresponding weight w_k, and satisfying:

$$\sum_{k=1}^{n} w_k = 1 \tag{1}$$

The comprehensive digital literacy score D_i for teacher i can be expressed as:

$$D_i = \sum_{k=1}^{n} w_k \cdot x_{ik} \tag{2}$$

The dimensions include digital cognition, technical application, human-machine collaboration, and digital ethics. Evaluation data were obtained by integrating survey questionnaires and behavioral data, and normalized using the range standardization method:

$$x_{ik} = \frac{X_{ik} - X_k^{\min}}{X_k^{\max} - X_k^{\min}} \tag{3}$$

To avoid arbitrariness in the "Mastery Level" indicator, this study defines mastery as the proportion of learning tasks completed within a given stage that meet a predefined proficiency threshold. Let N_t denote the total number of tasks in stage t and M_t the number of tasks meeting the mastery criterion; Mastery Level is calculated as:

$$\text{Mastery Level}_t = \frac{M_t}{N_t} \times 100\% \tag{4}$$

The mastery evaluation might demonstrate that a unified rubric consisting of three significant task types could establish performance levels: knowledge comprehension tasks, operational application tasks, and transfer output tasks. Each task type appears to use a 100-point scale, with scores $\geq$70 classified as mastered. Moreover, knowledge tasks may focus on concept tests and case judgments. Operational tasks could examine platform use and tool use. Given that transfer tasks assess instructional design outputs, transfer tasks might additionally evaluate human–AI collaborative activities. However, mastery values in Table 1 may show stage-by-stage calculation. Thus, the definition could ensure reproducibility and interpretability.

TABLE 1. Changes in Digital Literacy Scores, Time Investment, Efficiency, and Mastery Level for the Experimental and Control Groups

Indicator Category	Stage	Experimental Group	Control Group
Score	Initial score	45.2	45.0
	Stage 1 score	50.1	46.5
	Stage 2 score	55.3	48.0
	Stage 3 score	60.8	49.5
	Stage 4 score	65.4	51.0
Digital literacy gain (ΔD_i)	–	20.2	6.0
Time investment (hours)	Stage 1	10	9
	Stage 2	11	10
	Stage 3	12	11
	Stage 4	13	12
Efficiency (gain/time)	Stage 1	0.50	0.17
	Stage 2	0.52	0.15
	Stage 3	0.55	0.14
	Stage 4	0.58	0.12
Mastery level (%)	Stage 1	55%	50%
	Stage 2	65%	55%
	Stage 3	70%	60%
	Stage 4	75%	65%

C. AI-DRIVEN INTERVENTION DESIGN

The AI-enabled intervention could reasonably demonstrate that predicting teachers' digital literacy states and optimizing learning pathways might significantly incorporate AI readiness and learning engagement as critical constraint variables that appear to prevent over- or under-intervention. Moreover, the system may dynamically adjust learning resource allocation in accordance with teachers' actual capacity. Thus, this enables personalized and differentiated cultivation strategies. However, cultivation strategies may support optimized pathways.

Let $S_i^{(t)}$ denote the digital literacy state vector of teacher i at stage t. The intervention strategy vector $A_i^{(t)}$ consists of three controllable components: resource allocation intensity (number and difficulty of recommended units), task training intensity (quantity and complexity of practice tasks), and feedback frequency (immediate or stage-based). Based on

current states and historical trajectories, the AI model predicts the subsequent stage state.

$$S_i^{(t+1)} = f\left(S_i^{(t)}, A_i^{(t)}, \theta\right) \tag{5}$$

Where $A_i^{(t)}$ represents the intervention strategy vector, and θ denotes the model parameters. The system maximizes the digital literacy gain as the objective function:

$$\max_A \Delta D_i = D_i^{(t+1)} - D_i^{(t)} \tag{6}$$

The intervention strength and learning resource allocation are dynamically adjusted under constraints to implement personalized and differentiated digital literacy development plans.

D. SIMULATION EXPERIMENT PROCESS AND PARAMETER SETTINGS

The simulation experiment was conducted using discrete time iteration. At the initial time t=0, the teacher's initial digital literacy vector $S_i^{(0)}$ was input. At each stage, the teacher's state was updated based on the AI intervention strategy. The experiment process includes five steps: initialization, state evaluation, intelligent decision-making, intervention execution, and feedback correction. Let the simulation duration be T. The overall evolution process can be expressed as:

$$S_i^{(T)} = S_i^{(0)} + \sum_{t=0}^{T-1} \Delta S_i^{(t)} \tag{7}$$

Where $\Delta S_i^{(t)}$ is determined by the intervention strength coefficient, learning efficiency parameters, and individual response coefficients. By comparing the digital literacy increments of the experimental and control groups at the end of T, the effectiveness and stability of the AI-driven intervention mechanism were verified.

V. EXPERIMENTAL RESULTS AND DATA ANALYSIS

A. ANALYSIS OF OVERALL DIGITAL LITERACY DEVELOPMENT

This study examines the development of digital literacy in teachers working with AI, focusing on process-based measures rather than just overall performance. Key factors include time invested, capability development, and mastery level. The analysis compares two groups: one using an AI-enabled approach and the other using a traditional method. By evaluating data from different periods, the study reveals patterns of development and highlights differences between the two approaches, see Table 1.

Table 1 demonstrates that the experimental group could exhibit continuous increases in the overall scores, the learning efficiency, and the significant mastery level across all stages, with the important gains substantially exceeding those of the control group. Moreover, Mastery Level may be calculated as the stage-based proportion of tasks meeting the predefined threshold, reflecting objective task performance rather than subjective judgment. Given that these results appear to indicate enhanced learning efficiency, the AI-enabled approach might significantly enhance capability transfer. However, the control group may demonstrate slower improvement. Nevertheless, traditional training shows limitations in dynamic regulation.

B. ANALYSIS OF DIGITAL LITERACY IMPROVEMENT ACROSS DIMENSIONS

The measure of digital literacy for teachers includes four main elements: understanding digital concepts, using technical approaches, working with technology in combination with human practice, and following principles for digital conduct. The study examines these elements across time and compares differences between the group receiving treatment and the control group. Figure 2 shows the initial measure for each element of digital literacy, the final measure, and the degree of change that occurs.

C. ANALYSIS OF LEARNING PATH MATCHING AND INTELLIGENT RECOMMENDATION EFFECTS

Matching learning paths provides important evidence for assessing intervention precision. The study examines intervention effects by comparing matching levels between groups. Table 2 shows changes in path matching across stages.

TABLE 2. Learning Path Matching and Intelligent Recommendation Performance

Group	Initial Matching	Stage 1	Stage 2	Stage 3	Stage 4	Overall Gain
Experimental group	0.60	0.75	0.85	0.90	0.95	0.35
Control group	0.58	0.62	0.65	0.67	0.69	0.11

Results indicate that the group receiving intervention shows substantial improvement in matching, with levels increasing from 0.60 to 0.95 and approaching optimal values. The comparison group shows more limited improvement, with matching increasing from 0.58 to 0.69. These findings suggest that interventions using methods of this type provide more precise matching of learning paths and more effective use of resources for instruction.

D. COMPARATIVE ANALYSIS OF TRAINING MODEL EFFECTIVENESS

To examine the effectiveness of the training model using AI in comparison with the traditional approach, comparison of outcomes from training was conducted. Table 3 presents the overall performance of the two training models.

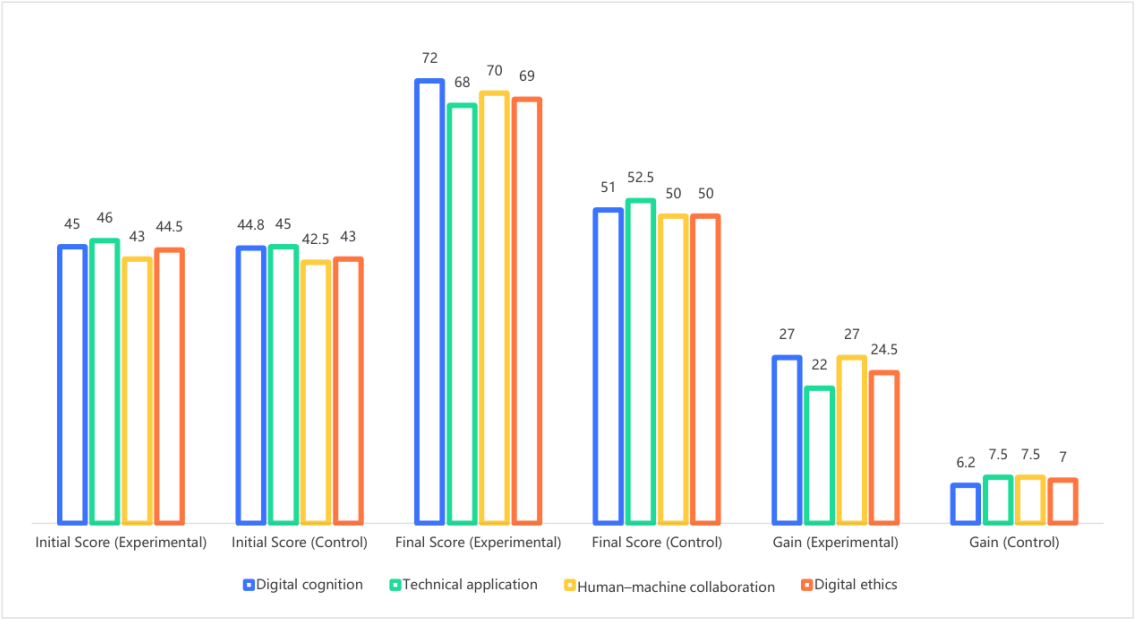

FIGURE 2. Changes and Gains in Digital Literacy across Dimensions

TABLE 3. Comparative Analysis of Training Model Effectiveness

Indicator	Experimental Group	Control Group
Initial digital literacy score	45.2	45.0
Final digital literacy score	65.4	51.0
Total digital literacy gain (ΔDi)	20.2	6.0
Average stage gain (points/stage)	5.05	1.50
Time-based gain (points/week)	1.68	0.50
Proportion of high-efficiency stages (%)	75%	25%
Overall learning efficiency index	High	Medium–low
Training model type	Personalized, adaptive	Unified, static

The results indicate that the experimental group achieved a substantially greater digital literacy gain than the control group. The AI-enabled model not only improved final learning outcomes but also enhanced training efficiency and stability, whereas the traditional model relied mainly on time accumulation with limited overall effectiveness.

VI. DISCUSSION

A. EFFECTIVENESS OF THE AI-ENABLED MECHANISM

The study findings show that the approach using machine systems provides strong support for developing skills in using digital tools among teachers in higher education. Analysis comparing multiple factors indicates that the training model using machine systems shows clear benefits in improving overall skills in using digital tools, providing learning paths that differ, and improving feedback that changes over time. The group receiving treatment showed substantially more improvement than the group that did not receive treatment, particularly in understanding digital tools and working with machine systems, and this reveals the particular role that machine systems provide in improving how teachers understand and use digital tools.

The significant improvement in matching learning paths also suggests that machine systems provide adaptive learning resources and specific support that differs across individuals and that these systems provide this support using data on individual features and progress in learning. This finding shows that the approach using machine systems provides feasibility and effectiveness in providing specific support, support that differs for individuals, and learning processes that change for individuals in developing skills in using digital tools among teachers.

B. STRUCTURAL CHARACTERISTICS OF DIGITAL LITERACY IMPROVEMENT

The findings show patterns in how teachers develop skills with digital technology. The analysis indicates that overall measures increase, but this also reveals development across different areas. Factors relating to understanding of digital systems, use of technical approaches, and work involving coordination between individuals and machines all show development that occurs together. These patterns suggest that improvement in digital skills is not simply adding separate technical abilities. The development that the data show involves changes across areas that include understanding, use of methods, and consideration of appropriate practices.

The approach using systems with artificial intelligence provided support that allowed development across these different areas. The model identifies areas where teachers show limitations and provides specific support for these areas. When the analysis compares this with approaches that follow previous methods for providing training, the model using artificial intelligence allows development that is more substantial. This occurs particularly for work that requires complex technical methods and understanding of appropriate use of digital systems. These results indicate that use of artificial intelligence is not only providing tools. The findings suggest that these systems allow more complete development of skills relating to digital technology.

C. MODEL APPLICABILITY AND RESEARCH LIMITATIONS

The experimental results may suggest that the AI-enabled mechanism could demonstrate significant effectiveness for developing the important digital literacy of teachers. However, limitations might nevertheless remain regarding the critical model applicability and the relevant generalizability. The sample was drawn from a single university and does not represent all disciplinary backgrounds, which may limit external validity. Given that in-service teachers were used as an application scenario, the proposed mechanism and intervention framework could be examined. Future research may involve larger samples across diverse disciplines and educational levels to further validate the model in broader educational contexts.

Although multiple aspects of digital literacy were measured, the methods may not fully capture the evolving demands of digital skills. Future studies should develop more comprehensive tools to assess these skills and accommodate technological changes.

The study focused on short-term effects, but digital literacy development is a long-term process. Future research should examine the sustained impact of AI-enabled approaches and how they align with teachers' long-term skill development needs.

VII. CONCLUSION

This study may empirically demonstrate that the AI-enabled mechanism could substantially enhance the critical digital literacy among higher education teachers. Moreover, the significant findings suggest that this AI-empowered approach improves overall digital literacy. Furthermore, results indicate improvements appear in digital cognition. However, the study may show technology application improved. Thus, findings suggest human-AI collaboration enhanced. Given that personalized learning pathways enable precise alignment, the intelligent interventions could indicate enhanced learning efficiency with teachers' learning needs. In light of the empirical evidence, these important findings may provide an innovative solution for developing teachers' digital literacy. Nevertheless, results highlight artificial intelligence demonstrates potential in education.

AUTHOR CONTRIBUTIONS

Conceptualization – Lisi Ba, Yashuang Hei, Bingxiao Zheng and Zhiju Zhao; methodology – Lisi Ba, Yashuang Hei and Zhiju Zhao; investigation – Lisi Ba, Yashuang Hei, Bingxiao Zheng and Zhiju Zhao; writing-original draft preparation – Lisi Ba, Yashuang Hei, Bingxiao Zheng and Zhiju Zhao. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research was supported by:

This work was supported by Innovation and Entrepreneurship Education Reform Project of Hebei Provincial Department of Education in 2025 (2025cxcy314), Social Science Planning Project of Xingtai City in 2025 (XTSKGH2025048).

HUMAN RESEARCH SUBJECTS

This study was approved by the Ethics Committee of Xingtai University, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

[1] R. V. M. Gowda, "Education 5.0: Evolution of promising digital technologies–A comprehensive review," International Journal of Advanced Science and Engineering, vol. 10, no. 2, pp. 3422-3448. doi 10.29294/IJASE.10.2.2023.3422-3448, 2023.

[2] Z. J. Jin, J. Fang, and X. Chen, "The impact of teachers' digital literacy on digital teaching competence: The chain mediating role of technology acceptance and psychological resilience," Journal of Teacher Education Research, vol. 37, no. 5, pp. 58-66, 2025, doi: 10.13445/j.cnki.t.e.r.2025.05.004.

[3] F. Li, "Content framework and pathway selection for teacher digital literacy development," China Distance Education, vol. 45, no. 9, pp. 74-88, 2025, doi: 10.13541/j.cnki.chinade.2025.09.005.

[4] C. Zhou, H. Y. Yang, J. P. Li, and M. Chen, "Evolutionary pathways and multi-level influencing mechanisms of teachers' digital literacy: An empirical analysis based on five-year large-scale data," China Educational Technology, no. 9, pp. 115-125, 2025.

[5] Y. Zhu, "Teachers' digital literacy and its improvement under the national digital education strategy," Teaching and Management, no. S1, pp. 50-54, 2025.

[6] J. Park, T. W. Teo, A. Teo, J. Chang, J. S. Huang, and S. Koo, "Integrating artificial intelligence into science lessons: Teachers' experiences and views," International Journal of STEM Education, vol. 10, no. 1, pp. 61, 2023, doi: 10.1186/s40594-023-00454-3.

[7] I. Celik, M. Dindar, H. Muukkonen, and S. Järvelä, "The promises and challenges of artificial intelligence for teachers: A systematic review of research," TechTrends, vol. 66, no. 4, pp. 616-630, 2022, doi: 10.1007/s11528-022-00715-y.

[8] T. L. Z. Sun and L. Zhang, "Technological accessibility and educational possibility: Chinese insights into AI education applications from DeepSeek," China Distance Education, vol. 45, no. 12, pp. 13-25, 2025, doi: 10.13541/j.cnki.chinade.2025.12.002.

[9] S. Wu, F. H. An, and R. J. Zhang, "Boundaries and collaborative mechanisms of artificial intelligence empowering education from a functionalist perspective," Theory and Practice of Education, vol. 45, no. 34, pp. 25-30, 2025.

[10] S. Zulfiqar, B. Sarwar, C. Huo, X. Zhao, and H. Mahasbi, "AI-powered education: Driving entrepreneurial spirit among university students," The International Journal of Management Education, vol. 23, no. 2, Art. no. 101106, 2025, doi: 10.1016/j.ijme.2024.101106.

[11] S. Thapa and S. Bankira, "Digital literacy skills among higher secondary students: Demographic differences and educational implications," Asian Journal of Education and Social Studies, vol. 51, no. 12, pp. 183-195, 2025, doi: 10.9734/ajess/2025/v51i122685.

[12] H. Mondal, G. Marndi, J. K. Behera, and S. Mondal, "ChatGPT for teachers: Practical examples for utilizing artificial intelligence for educational purposes," Indian Journal of Vascular and Endovascular Surgery, vol. 10, no. 3, pp. 200-205, 2023, doi: 10.4103/ijves.ijves_37_23.

[13] Z. H. Zeng, "Teachers' digital literacy oriented toward national development strategies: Opportunities, practical challenges, and pathways," Higher Education Exploration, no. S2, pp. 144-146, 2025.

[14] M. Alwaqdani, "Investigating teachers' perceptions of artificial intelligence tools in education: potential and difficulties," Education and Information Technologies, vol. 30, no. 3, pp. 2737-2755. doi 10.1007/s10639-024-12903-9, 2025.

[15] K. Lin and M. F. Liu, "Innovative pathways for teacher digital literacy development from the perspective of game functionalism," Contemporary Education Science, no. 1, pp. 55-65, 2025.

[16] L. Bai, G. T. Li, and Y. T. Sun, "Constraints and solutions for digital literacy development of vocational teachers from an ecological perspective," Vocational and Technical Education, vol. 46, no. 4, pp. 52–58, 2025.

[17] L. Luo, "Pathways for teacher digital literacy development: International insights and the Chinese approach," Primary and Secondary School Management, no. 5, pp. 17-20, 2024.