Research on Intelligence-Driven AI Literacy Education in University Libraries: Collaborative Mechanisms, Practical Models, and Implementation Pathways*

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Abstract

Artificial intelligence (AI) technology is reshaping the ecological landscape of higher education, and university libraries face a strategic opportunity to transform from resource providers into hubs for AI literacy education. At present, AI literacy education still faces the "last mile" implementation challenge. Through model induction and framework construction, this paper systematically explores the practical dilemmas and development paths of AI literacy education in university libraries. First, by investigating the practice of AI literacy education in university libraries, it analyzes current bottlenecks such as uneven resource allocation, poor articulation of educational content, and lagging educational methodologies. Second, based on an intelligent theoretical model of AI literacy education underpinned by the PPDCA cycle, it constructs a library-led intelligent collaborative mechanism from three dimensions: "data-knowledge" conjugation, spatiotemporal folding, and meaning resonance. Finally, it reconstructs the library as a five-in-one collaborative hub integrating the roles of "demand observer—solution architect—scenario builder—value gatekeeper—system optimizer," providing a theoretical basis and practical paradigm for advancing AI literacy education in universities at scale.

Full Text

[**Special Topic: AI Literacy Education**]

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Abstract Artificial intelligence (AI) technology is reshaping the ecology of higher education, and university libraries are facing a strategic opportunity to transform from resource providers into hubs of AI literacy education. At present, AI literacy education still encounters the "last mile" difficulty of implementation. Through model induction and framework construction, this paper systematically explores the current situation and development pathways of AI literacy education in university libraries. First, by investigating AI literacy education practices in university libraries, it analyzes current bottlenecks such as uneven resource allocation, unsmooth linkage of educational content, and lagging educational methodology. Second, based on an intelligent AI literacy education theoretical model grounded in the PPDCA cycle, it constructs a library-led intelligent collaboration mechanism from the three dimensions of "data-knowledge" conjugation, spatiotemporal superposition, and meaning resonance. Finally, it reconstructs the library as a five-in-one collaborative hub comprising "needs insight analyst—solution architect—scenario builder—value gatekeeper—system optimizer," providing theoretical foundations and practical paradigms for the scaled advancement of AI literacy education in universities.

[**Keywords**] AI literacy education; university libraries; intelligence-driven

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Introduction

In 2021, the state issued the *Guiding Opinions on Promoting the Construction of New Educational Infrastructure and Building a High-Quality Educational Support System* and launched the "Strategic Action for Educational Digitalization," thereby laying the policy foundation and clarifying the direction of development for university informatization construction. In April 2025, the Ministry of Education and eight other departments adopted the *Opinions on Accelerating the Advancement of Educational Digitalization*, explicitly proposing that educational digitalization should serve as a breakthrough point for building an "artificial intelligence large model for education," support universities in carrying out AI integration pilots across the entire chain of teaching, research, evaluation, and governance, open up new tracks for educational development, and shape new advantages for development. On July 31, 2025, an executive meeting of the State Council reviewed and adopted the *Opinions on Further Implementing the "Artificial Intelligence+" Action*, providing comprehensive and in-depth theoretical reference and practical guidance for the digital transformation of higher education. Against this background, university libraries, as the principal venues for information literacy education[1], urgently need to realize a role transition from resource providers to hubs of AI literacy education.

At present, international research mainly unfolds across three levels: comprehensive frameworks, role customization, and application models. At the level of comprehensive frameworks, scholars have systematically sorted out the core competencies and design considerations of AI literacy[2–4], and, through systematic reviews, clarified its practical achievements and evolutionary trends[5]. At the level of role customization, studies have constructed competency frameworks for the two groups of students and teachers respectively[6–7], and designed for librarians a seven-dimensional framework that integrates scenario-driven orientation, ethics-first principles, and dynamic cognition[8]. At the level of application models, generative artificial intelligence (Generative Artificial Intelligence, GenAI) has reshaped multimodal writing through customizable images and recursive prompting processes, breaking through the long-standing text-centered boundaries of AI literacy and expanding the adaptable scenarios for GenAI pathways in education[9]. Meanwhile, some studies have proposed an optimized EDUCAUSE AI literacy framework, aiming to bridge the gap between teaching content and practical competencies[10].

Domestic research mainly focuses on three major issues. The first is the construction of AI literacy frameworks. The academic community generally recognizes a ternary structure[11], but there remain differing views on the division of dimensions: Huang Ruhua et al.[12] argue that the content framework of AI literacy education in China consists of four major parts—AI cognition, AI skills, AI application, and AI ethics; Cai Yingchun et al.[13] introduce the KSAVE model to construct an AI literacy framework. The second concerns implementation pathways for education. Most studies emphasize library-led tiered teaching and scenario-based curriculum design. For example, Chu Jiming[14] points out that libraries need to implement differentiated teaching for freshmen, senior undergraduates, and graduate students, forming a "tiered continuous education" system, and

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integrates courses, lectures, embedded instruction, and other diverse scenarios so as to precisely meet the needs of different groups. Third is application in specific scenarios, mainly covering concrete contexts such as research support and course embedding. For example, the Sichuan University Library has collaborated with multiple colleges to develop interdisciplinary AI education projects, embedding them into specialized courses to explore applications of generative AI tools; Wuhan University Library has carried out activities such as "AIGC-themed training,"combining them with research scenarios to help faculty and students master the use of AI tools[^15]. However, an in-depth analysis of existing studies shows that AI literacy education practices in university libraries are generally constrained by three major bottlenecks: educational activities are mostly one-off lectures or workshops and cannot form coherent, progressive learning experiences; teaching content is often disconnected from departmental and disciplinary requirements as well as students' learning needs, with collaboration remaining at the formal level; and insufficient intelligent driving forces lead to rigid educational models. Moreover, the update cycle of traditional courses is measured by semesters, making it difficult to respond dynamically to rapidly evolving AI technologies and students' personalized learning needs.

From the perspective of practice, AI literacy education at home and abroad has already shown a trend toward collaborative innovation between universities and libraries. The University of Arizona in the United States has embedded ChatGPT into information literacy courses and built an ethics discussion module on an AI contract generator, achieving an organic integration of tool application and value reflection. In China, university libraries in Tianjin, Jiangxi, Hubei, Sichuan, and other regions have already carried out AI literacy education practices, mainly exploring pathways through seminars and tiered courses, such as case-sharing sessions and AI drawing workshops. Yet these measures are mostly "point breakthroughs" or "localized improvements," and have failed to fundamentally resolve the above-mentioned problems.

As a result, the "implementation dilemma"of AI literacy education in universities has become increasingly prominent: on the one hand, there is an urgent demand at the level of national strategy; on the other, the existing practical paradigms are intrinsically weak. This enormous tension indicates that we urgently need a new top-level design—one that must be systematic, intelligence-driven, and deeply collaborative—in order to replace the current fragmented mode of practice. To construct this new paradigm, university libraries are not merely an appropriate choice, but an inevitable strategic fulcrum. First, as neutral interdisciplinary platforms, libraries can effectively break down departmental barriers and integrate university-wide resources. Second, as data hubs within the university information ecosystem, the user behavior data held by libraries constitute fertile ground for intelligent and personalized education. Third, AI literacy education is, in essence, the extension and upgrading of information literacy in the intelligent era, and is an inherent part of the library' s core educational function.

In summary, this paper is situated in the dual context of the above-mentioned "implementation dilemma" and "call for role repositioning." Focusing on the implementation challenges of AI literacy education in university libraries, it follows the logical thread of "framework—pathway—collaboration" : by constructing a theoretical model for intelligence-driven AI literacy education in university libraries, designing technology-enabled implementation pathways, and establishing a library-led multi-stakeholder collaboration mechanism, it aims to fill the research gap from the perspective of intelligent driving, solve the "last-mile" problem in AI literacy education, and provide university libraries with a replicable and scalable practical paradigm.

1 Practical Models of AI Literacy Education in University Libraries

1.1 Practices of AI Literacy Education in University Libraries

To systematically understand the current state of AI literacy education in Chinese university libraries, this paper adopts multiple methods to identify and summarize models. First, through bibliometric analysis, 199 relevant articles indexed in databases such as CNKI and Wanfang from January to September 2021 were retrieved, and key practice cases were extracted from them. Second, a systematic survey was conducted of the official websites of "Double First-Class" university libraries to collect information on their activities related to AI literacy education. Finally, based on an analytical framework composed of three dimensions—educational carrier, time span, and organizational depth—existing practices were summarized into three main models. In practice, these three models are not mutually isolated, but are interrelated and each has its own emphasis.

1.1.1 Course-Integration Model This type of practice takes formal credit-bearing courses as its main carrier[^16]. Relying on the mature teaching management systems and rigid constraints of the credit system in universities, it promotes the systematic transmission of AI literacy knowledge through the collaborative design of syllabi by the library, the office of academic affairs, and departments. For example, Chongqing University Library arranges for librarians with professional disciplinary backgrounds to participate deeply in course design and teaching[^17], thereby realizing deep internalization of knowledge through institutionalized pathways. In other representative cases, Shanghai International Studies University has built an AI literacy framework based on the KSAFE model, covering five dimensions—knowledge, skills, attitudes, values, and ethics—and precisely aligning it with teaching objectives and course evaluation standards. Jianghan University, meanwhile, has integrated literature analysis tools into a course on social science research methods, requiring students to complete the practical task of "AI-assisted research trend analysis." The advantage of this model lies in ensuring the standardization and breadth of educational coverage, but its deeper contradiction is that there is an inherent conflict between the "stability" pursued by the formal teaching system and the "agility" required by AI technology iteration and faculty development. On the one hand, AI technology iterates rapidly on a monthly basis, whereas the revision cycle of course syllabi is usually measured in years, making teaching content highly prone to lagging behind. On the other hand, "dual-competency" instructors who possess both disciplinary backgrounds and cutting-edge AI skills are difficult to cultivate at scale through short-term training. Therefore, problems such as insufficient faculty reserves, excessive burdens on librarians, and complicated credit-recognition procedures are not accidental phenomena, but inevitable outcomes of the contradiction between a "heavy system" and "fast demand."

1.1.2 Resource-Navigation Model This type of practice centers on thematic and interactive online portals, supporting users in carrying out self-directed learning according to their own needs by integrating multi-level resources. Such platforms usually adopt a three-layer architecture of "tools—cases—ethics": the tools layer provides basic resources such as ChatGPT operation guides and Python libraries; the cases layer provides examples of AI-assisted thesis writing and data visualization templates; and the ethics layer provides content such as academic integrity handbooks and copyright risk checklists[^18]. For example, most university libraries make use of

User-scenario adaptation technology relies on a "reader profiling system" to provide differentiated services for users in different disciplines. Its internal logic is to use the scale effects and technological advantages of online platforms to aggregate massive resources and build an all-weather, low-threshold entry point for self-directed learning, with the goal of becoming an intelligent "AI knowledge steward." However, the current platform' s intelligent recommendation algorithms have not yet been deeply integrated with users' disciplinary backgrounds, resulting in limited accuracy in resource matching. At the same time, in meeting users' personalized and deeper-level needs, the problem of "failure of precision services" still exists, which has also become a major obstacle in the "last mile" implementation of this model.

1.1.3 Activity-expansion model

This type of practice uses short-term projects such as workshops, competitions, and academic salons to rapidly stimulate students' learning interest and teach practical skills, training students' ability to apply AI tools and make ethical judgments in real-life contexts. For example, Peking University' s information literacy workshop[^19] organized an ethics debate on the topic "Should AI-generated abstracts be labeled?", guiding students to think deeply about academic norms; Wuhan University Library issued skill-certification badges through its "90-minute lecture" program to consolidate learning outcomes in a timely manner.

Although these projects take diverse forms, they are still generally constrained by a "one-off" predicament: they face a contradiction between the "instantaneity" of activity experience and the "long-term nature" of literacy internalization, making it difficult to transform the knowledge and skills gained through short-term participation into lasting competencies. In addition, a single activity can cover only part of the knowledge points, making it difficult for learners to form a complete competency system. Follow-up scientific assessment of learning outcomes is also lacking, making it difficult to generate a basis for improvement; as a result, in the "last mile" implementation stage, it is difficult to achieve sustainable and cumulative educational results.

1.2 Explicit difficulties and causes in actual cases

The bottlenecks of the above three models do not exist in isolation. The difficulties they present—such as lack of connection in curriculum systems, insufficient resource adaptability, and fragmentation of teaching activities[^20]—jointly reveal two deeper, more fundamental cruxes constraining the development of the entire ecosystem.

1.2.1 Resource allocation: regional disparities and data barriers

The effective advancement of AI literacy education depends heavily on "new infrastructure" such as computing power and data, yet the allocation of these core resources among Chinese universities shows significant structural imbalance. On the one hand, disparities between eastern and western regions, as well as among universities at different levels, in hardware facilities and database access conditions directly constrain the inclusive development of education. The high access costs of commercial databases and strict API-call restrictions make it difficult for most non- "Double First-Class" universities to obtain high-quality corpora[^21]. These restrictions exclude some universities from high-quality AI education systems and intensify the educational digital divide warned of by the United Nations Educational, Scientific and Cultural Organization (UNESCO). On the other hand, even in leading universities with relatively abundant resources, data resources are often dispersed across different departments or platforms, forming "data silos" and making it difficult for libraries to conduct behavior analysis of users across the whole domain. This is the deeper institutional cause of the insufficient service precision of the "resource-navigation" model. In addition, existing collaborative mechanisms such as the China Academic Library & Information System (CALIS) have difficulty effectively breaking through institutional barriers, highlighting their institutional defects.

To break this impasse, it is necessary to build a tripartite collaborative ecosystem of "library-university-enterprise," led by education authorities and jointly developed with publishing institutions to create cross-regional academic-resource sharing databases, thereby promoting the integration of computing power and corpora. At the same time, social forces should be attracted to participate, channels for resource sources should be broadened, and implementation should proceed in stages, with priority given to strengthening policy safeguards and pilot-project layouts, so as to ensure the fairness and sustainability of resource allocation.

1.2.2 Educational design: content gaps and methodological lag

At present, AI curriculum systems in domestic universities that can effectively connect with basic education and realize continuous cultivation of competence remain few. This also means that the absence of curriculum articulation is continuously intensifying the structural gap in students' AI competence. Specifically, first, AI ethics courses at the higher-education stage mostly remain at the level of theoretical instruction and lack practical scenarios, which runs counter to the eight-level continuity-of-competence application principle emphasized by the European Digital Competence Framework for Citizens (DigComp)[^22]. Second, only 23% of domestic universities have offered some courses integrating particular disciplines with AI, whereas Finland has achieved 100% disciplinary coverage through a "professional-situation simulation platform" [^23]. Third, teaching-method updates lag behind; most AI courses in universities are still dominated by theoretical explanation[^24] and have not fully adopted methodologies such as the four-step approach recommended by UNESCO: experiencing bias, attribution analysis, technical correction, and ethical debate[^25].

In response to the above problems, it is recommended that, at the curriculum level, reference be made to the STEM interdisciplinary literacy framework to build a teaching pathway of "core concepts—technical practice—disciplinary scenarios." In terms of faculty, a tripartite certification system involving libraries, schools of artificial intelligence, and enterprises should be established, and librarians should be required to complete updated AI teaching-competency training every year. At the same time, AI ethics practice should be incorporated into the evaluation-index system for information literacy education in universities, reversing the traditional evaluation tendency of "emphasizing skills while neglecting critical reflection" and forming an orientation that gives equal weight to skills and critical thinking.

2 Collaborative mechanism for AI literacy education in university libraries driven by intelligentization

2.1 Framework model and explanation

Against the era background in which intelligent technologies are driving educational transformation, AI literacy education in university libraries faces an urgent need for systematic upgrading. The traditional PDCA (Plan-Do-Check-Act) cycle[^26], as a quality-management tool, with its core characteristics of continuous improvement and cyclical iteration, provides a basic framework for responding to the rapid evolution of AI technologies and the dynamic changes in user needs. Moreover, the wide application of this model in the field of education has also demonstrated its effectiveness in constructing a dynamic quality-assurance system[^27].

However, in the emerging and complex scenario of AI literacy education, the traditional PDCA cycle also reveals its structural limitations. Its process begins with "planning" (Plan), implicitly assuming that the problem has already been clearly identified.

definition. When facing a complex educational ecology, changing adaptive technologies, and the needs of multi-party collaboration, this can very easily lead educational design into the misconception of "technology for technology' s sake," rather than being genuinely problem-driven.

To this end, on the basis of the traditional PDCA model, this study places the "problem identification" stage at the front and constructs a PPDCA (Problem-Plan-Do-Check-Act) framework. The theoretical basis of this stage derives from the needs assessment theory proposed by Kaufman R et al. [28]. Through the analytical framework of "current state—desired state—gap," it systematically diagnoses the precise gap between learners' current ability levels and the goals of AI literacy cultivation. This structured method transforms vague perceptions of problems into clear and measurable educational needs, ensuring that subsequent planning and implementation focus on bridging accurately identified capability gaps. Through this front-loaded diagnostic mechanism, the PPDCA framework safeguards the relevance and effectiveness of educational design from the source, thereby constructing a theoretical model that better fits the characteristics of AI literacy education (see Figure 1).

Text in the figure

- **Objective layer:** Solve the "last mile" problem in implementing AI literacy education.
- **Process layer**
  - **Problem identification**
    - Intelligent problem diagnosis
    - Multi-source data fusion to locate educational pain points
  - **Planning**
    - Algorithm-assisted collaborative planning
    - Generate dynamic plans and constrain the rights and responsibilities of multiple parties
  - **Execution**
    - Digital-twin scenario execution
    - Dynamic teaching optimization through virtual–real mapping
  - **Action**
    - Reinforcement-learning evolution
    - Feedback-based iterative intelligent decision-making
  - **Check**
    - Causal effectiveness evaluation
    - Multi-dimensional attribution to verify educational value
  - Main closed loop; secondary closed loop; bidirectional.
- **Subject layer:** Library; teachers and students; enterprises; other departments.
- **Intelligent technologies**
  - Natural language processing
  - Clustering algorithms
  - Reinforcement learning
  - Digital twins
  - Multi-agent simulation
  - Multitask learning
  - Privacy sandbox
  - Smart contracts

- **Sustainably evolving intelligent ecosystem**
  - Driven; carrier; empowerment.
- **Bottom process**
  - Problem identification → predictive output → planning → rights-and-responsibilities clauses / smart contracts / multi-party subjects / tracking system → execution filing → execution → real-time data / digital twins / simulation deduction → check → attribution analysis → action
  - Structured problems; algorithmic decision-making hub; dynamic planning schemes; strategy evolution.

Figure 1. Theoretical model of AI literacy education in university libraries driven by intelligentization

The theoretical model of AI literacy education driven by intelligentization and based on the PPDCA framework consists of an objective layer, a process layer, and a subject layer. In the process layer, the model systematically optimizes the implementation pathway of AI literacy education through the cyclical iteration of five stages: problem identification (Problem), planning (Plan), execution (Do), check (Check), and action (Act). Each stage embeds specific intelligent technologies as supporting carriers, such as natural language processing, clustering algorithms, reinforcement learning, and digital twins, thereby enabling the intelligent and automated operation of the educational process.

(1) In the problem identification stage, the core task is to use intelligent technologies to gain deep insight into educational pain points, accurately identify problems, and anticipate potential risks, so as to avoid resource mismatch and design deviation at the source. In concrete practice, this process is realized through three levels of technological application: first, university libraries deploy semantic analysis systems to transform scattered textual information into structured demand maps, providing semantic-layer support for full-domain user behavior analysis systems; second, through API interfaces, they monitor the usage trajectories of digital resources in real time and identify latent needs in behavioral data; third, they build a multi-dimensional perception system and use technologies such as biosensing to comprehensively capture learning difficulties.

(2) In the planning stage, cross-subject collaborative planning is mainly carried out. As the coordinating hub, the library builds a resource-matching platform; uses smart contracts to clarify the resource contributions and allocation of rights and responsibilities among departments, enterprises, and libraries; and applies clustering algorithms to stratify learners and generate tailored educational pathways for them. These tasks directly support the subsequent generation of personalized plans and the integration of cross-departmental resources.

(3) In the execution stage, PPDCA relies on smart contracts and digital twin technologies to build an efficient multi-subject collaboration network.

Through multitask learning and reinforcement-learning evaluation models, it realizes embedded monitoring and quantitative indicators, thereby supporting multi-dimensional attribution analysis of educational outcomes.

(4) In the check stage, causal effectiveness evaluation is carried out, and educational value is verified through multi-dimensional attribution, providing feedback for a new round of problem identification, ensuring that educational design always aligns with real needs and achieving continuous iterative optimization.

(5) In the action stage, resource allocation strategies are continuously optimized based on reinforcement learning technologies, realizing a transformation from passive service to proactive empowerment,

continuously optimizing educational strategies and implementation pathways.

2.2 Intelligent Collaborative Mechanism

2.2.1 Field-Capability Evolution Mechanism Based on the PPDCA Cycle

In the intelligent era, AI literacy education in colleges and universities is no longer a linear question of "who teaches" or "what to teach"; its core has shifted toward how multiple actors can jointly build an educational system that is sustainable and capable of self-evolution. Relying on its dual attributes as a knowledge intermediary and a data hub, the library can be abstracted as a site for collaborative regulation. It does not govern directly, but continuously transforms dispersed educational potential energy into collaborative kinetic energy. Luo Wei et al. [29] argue that the core of Bourdieu' s field theory [30] lies in transforming dispersed social potential energy into observable relational structures through correspondence analysis; its nonlinear, relational, and iterative characteristics provide the epistemological and methodological basis for the library to serve as a site of collaborative adjustment. Within such a site of collaborative adjustment, with the library as the origin, a nonlinear field is formed in which knowledge, technology, and context are integrated. This field takes the iterative speed of PPDCA as its intensity variable, rather than administrative hierarchy as its operating logic, and uses energy-level transition as a metaphor for the spiral improvement of educational capacity. Here, "energy level" refers to different levels of AI literacy, such as moving from the basic level of "tool operation" to higher-order levels of "algorithmic critique" and "ethical reflection." The goal of the PPDCA cycle is to identify widely existing low-level capability gaps at the problem-identification stage, and, through a series of collaborative activities, to realize a collective transition toward higher-level core literacy at the action stage.

Specifically, at the problem-identification stage, the library uses domain-wide multimodal data scanning to translate originally fragmented needs into a macroscopic map of energy-level distribution, thereby triggering the self-organizing tendency of multiple actors [31]. At the planning stage, the actors are no longer assigned tasks; rather, within the collaborative field, they jointly calculate an optimal path for energy-level transition. This path itself is a predictive equation for the future distribution of educational energy. At the execution stage, the library provides experimental conditions, enabling transient nodes such as teachers and students, departments, and enterprises to function as minimal educational units and complete local transitions [32]. The whole process can be regarded as an experiment in the folding of educational energy across the dimensions of time and space. At the checking stage, the system replaces traditional effect evaluation with energy-level conservation verification, using feedback loops to verify whether educational energy has truly transitioned from a low energy level to a high energy level, rather than merely remaining at the achievement of superficial indicators. Energy-level conservation verification cannot use a traditional set of KPIs to measure whether outcomes have met standards; instead, it requires abstracting the overall state of AI literacy education into a set of computable educational-energy dimensions, and using certain operations to confirm that energy has transitioned upward without dissipation. At the action stage, the high-energy-level structure itself becomes a new source of disturbance, reversely reshaping the initial problem-identification stage, causing the collaborative gravitational field to expand again and enter the next round of energy-level transition. Thus, a never-closed cycle that always maintains conservation is formed. The above cycle constitutes a library-led intelligent collaborative mechanism, transforming collaboration from experiential negotiation into a computable, verifiable, and scalable systematic process.

2.2.2 Multiple Connection Mechanism Based on the Collaborative Field

When the university library is abstracted as a collaborative field, its relationship with departments and enterprises transcends traditional data exchange and one-way knowledge supply, presenting multilayered, structured multiple connections.

(1) The first layer is the conjugacy of data and knowledge. This is a bidirectional, real-time feedback and calibration mechanism. The data field constructed by the library and the knowledge field represented by departments and enterprises form a pair of conjugate variables. Any slight fluctuation in the data field, such as a sudden shift in students' search hotspots, will be mapped in real time onto the knowledge field, prompting departments to fine-tune syllabi or enterprises to update cases; conversely, a new algorithm white paper released by an enterprise will also instantly produce observable reverberations in the data field. The two remain symmetrical in the mathematical sense: any phase change on one side will immediately cause phase compensation on the other side, namely immediate response and mutual calibration, thereby ensuring that the entire collaborative system reaches a zero-delay state.

(2) The second layer can be summarized as spatiotemporal folding. In tra-

ditional teaching, "design—implementation—evaluation—improvement" is usually regarded as four discrete stages, whereas the real-time iteration of PPDCA compresses them into a nearly parallel dynamic process, achieving an agile state in which evaluation is teaching and improvement is design, thereby eliminating iterative delay. At the same time, with the help of digital twin technology, the library integrates the data flows of the physical campus and the cloud environment. All learning behaviors of students in laboratories, enterprise internship posts, or inside the library are synchronized within the twin system to a unified contextual coordinate, thereby eliminating the spatial differences between on-campus and off-campus settings. Together, the two construct a new type of borderless educational field.

(3) The third layer manifests as semantic resonance of educational goals. When collaborative practice accumulates to a certain extent, all actors' understanding of AI literacy undergoes a synchronized and deep-level transformation: students transition from "tool use" to "ethical understanding" ; teachers shift from "skill transmission" to "cultivation of a critical spirit" ; and enterprises move from "efficiency first" toward "assuming social responsibility." This collective sublimation at the cognitive level marks the overall evolution of educational goals within the field from "skills-based" to "literacy-based."

3 Intelligent Implementation Pathways for AI Literacy Education Based on the PPDCA Cycle

3.1 Problem Diagnosis Stage—Demand Insight Provider

As the initial stage of the PPDCA cycle, problem diagnosis has as its core task the systematic identification and analysis of the gap between the current state of AI literacy education and the expected goals. In an intelligent educational environment, this stage has gradually shifted from traditional evaluation that relies on questionnaires and interviews toward a data-driven, continuous cognitive process with capabilities for in-depth analysis and dynamic monitoring. Its goal is to rely on intelligent technologies to accurately identify the actual shortcomings and potential needs of teachers and students in AI cognition, skills application, ethical awareness, and other aspects, thereby providing an accurate basis for subsequent teaching.

To establish an effective problem-diagnosis mechanism, university libraries should focus on the following design points. First, they should build a domain-wide user behavior analysis system. By deploying unobtrusive learning-behavior tracking tools and integrating multisource information—such as library database search logs, records of AI tool use (e.g., reference management and data analysis software), and interaction data from online learning platforms—they can form comprehensive user profiles. Second, they should implement intelligent auditing and content analysis. Using natural language processing and machine learning technologies, libraries can conduct batch analyses of texts such as course assignments, academic papers, and graduation projects. This can not only identify traces of AI assistance, but also reveal common problems caused by overreliance on or misuse of AI, such as weak argumentation, insufficient information-integration ability, and inadequate critical thinking[^33]. Third, they should establish a dynamic demand-feedback loop. By introducing intelligent Q&A robots based on large language models and deploying them on library portals and course platforms, libraries can enable these systems not only to respond to inquiries but also to proactively capture and cluster high-frequency questions, thereby sensing changes in educational needs in real time.

3.2 Planning and Formulation Stage–Program Architect

The core task of the planning and formulation stage is to design a systematic, personalized, and operable AI literacy education program based on the results of problem diagnosis. As program architects, libraries need not only to plan course content[^34], but also to build a collaborative network that integrates internal and external resources, so as to ensure that educational programs can accurately match the needs of different learners and are feasible for implementation. This means that the plan should be forward-looking, systematic, and collaborative. For example, libraries can use the user data obtained during the problem-diagnosis stage and apply collaborative filtering or content-based recommendation algorithms to generate personalized AI literacy learning manuals for teachers and students. Such manuals may include recommended courses, reading materials, practical projects, expert resources, and other content.

Taking the Sichuan University Library’ s response to the impact of ChatGPT as an example, it did not stop at holding isolated lectures, but instead carried out a systematic curriculum restructuring. In 12 information literacy courses for undergraduates, master’ s students, and doctoral students, it incorporated general AI literacy modules, including technical principles, application scenarios, limitations, and other content. Going further, the library collaborated with the School of Economics, the College of Literature and Journalism, the School of Public Administration, and others to promote embedded teaching[^35]. For example, in courses jointly offered with the School of Economics, the focus was on how to use AI for macroeconomic data forecasting and quantitative model construction; in collaboration with the College of Literature and Journalism, the focus was on how to use generative AI to assist creative writing and identify fake news generated by AI.

3.3 Implementation Stage–Scenario Builder

The implementation stage is the key link in transforming educational programs into concrete practice. Its core lies in constructing diverse and immersive teaching scenarios and realizing dynamic regulation of the teaching process. In this process, the library, as a scenario builder, needs to use technologies such as AI, VR/AR, and digital twins to create a blended virtual-real learning environment that goes beyond the traditional classroom, enabling learners to master AI application skills in highly simulated situations and to develop their capacity for ethical judgment.

To achieve this goal, a teaching environment based on digital twin technology can be gradually constructed through high-precision digital modeling of physical library spaces, data resources, and research workflows. For example, a digital twin library can be built on a metaverse platform, enabling students to conduct simulations of high-cost or high-risk AI operations under risk-free conditions. At the same time, an adaptive learning platform can be built on the basis of learning analytics technology. According to learners' real-time behaviors—such as response speed, error types, and browsing trajectories—the difficulty and presentation mode of teaching content can be dynamically adjusted. In addition, ethical risk prevention and control mechanisms must be embedded in the design of teaching systems[^36], including improving the transparency and explainability of algorithmic decision-making. For example, explainable AI technology can be used to clarify to students the basis for literature recommendations, and a strict data privacy protection framework should be established, following the principles of "informed consent" and "minimum necessity" [^37] to regulate the collection and use of learning data.

3.4 Inspection and Evaluation Stage—Value Gatekeeper

The inspection and evaluation stage aims to conduct a systematic examination and value judgment of the implementation effects of AI literacy education. Its core task is to measure whether educational activities have achieved their preset goals and to deeply analyze the causes of both achievements and shortcomings. As value gatekeepers, libraries need not only to assess students' mastery of technical skills, but also to attend to the formation and internalization of their AI ethics awareness and capacity for responsible innovation. The evaluation system at this stage should be multidimensional and process-wide, and should be able to effectively address the new challenges to academic integrity brought about by AI technologies. To this end, an evaluation mechanism should be constructed in which technology and ethics operate along dual tracks. On the one hand, AI skills automated assessment tools may be introduced or developed, such as online judge systems (OJ) and data-processing capability testing platforms, so as to use quantitative indicators to track learners' comprehensive ability progression from data cleaning and feature engineering to model application. On the other hand, a clear manual arbitration mechanism should be established to review complex, ambiguous, or high-risk cases identified by automated systems, thereby remedying the limitations of purely technical evaluation and ensuring the fairness of evaluation results and the completeness of their educational significance.

3.5 Action Improvement Stage—System Optimizer

Action improvement is the closing node of the PPDCA cycle and also the engine that drives the entire AI literacy education system to rise in a spiral manner. This stage aims to transform the conclusions and lessons learned from the inspection and evaluation stage into concrete and systematic improvement measures, and to solidify them into new standards, processes, or systems, thereby initiating a higher-level iterative cycle. In this process, libraries need to demonstrate forward-looking vision and system-optimization capabilities, realizing a transformation from passive response to active evolution. Specifically, a strategy automatic-optimization model can be constructed. Using data obtained in the evaluation stage—such as students' academic performance, ability shortcomings, course feedback, and the effectiveness of teaching strategies—as input, reinforcement learning models can be trained to determine the optimal combination of teaching strategies that can maximize the improvement of students' comprehensive literacy. And

At the same time, to achieve the continuous evolution of human–machine collaboration, the improvement suggestions generated by the reinforcement-learning model—such as adjusting the difficulty of a course module or replacing a teaching case—need to be pushed to the instructional design team in the form of optimization proposals. They should then be implemented only after expert review, correction, and refinement. This mechanism not only integrates human-machine collaborative intelligence, but also ensures that technology-driven improvements always remain aligned with educational principles and humanistic values.

4 Conclusion

This study unfolds according to the logic of "framework—path—collaboration." In the first stage, on the basis of integrating AI literacy education practices in university libraries at home and abroad, it identifies three typical models: curriculum-integration, resource-navigation, and activity-expansion models. It also distills such explicit difficulties as uneven resource allocation, poor articulation of educational content, and lagging educational methodology. In the second stage, taking the PPDCA cycle as its foundation and moving the problem-identification link to the front, the study constructs an intelligence-driven theoretical model and redefines the university library as a collaborative field. In the third stage, around the five stages of needs insight, solution architecture, scenario construction, value evaluation, and system optimization, it integrates various intelligent technologies and constructs an intelligent collaboration mechanism from the three dimensions of actors, technology, and institutions, thereby forming a replicable implementation paradigm. Based on the above analysis, this paper draws the following conclusions: The core crux of the difficulty in implementing AI literacy education in university libraries is not simply a shortage of resources, but rather the rupture of the "needs—content—context" chain and the fragmentation of cross-actor collaboration. By using the PPDCA framework to move the problem-identification stage forward, university libraries can shift from being resource guarantors to realizing role transitions as needs analysts, solution architects, scenario builders, value gatekeepers, and system optimizers. The introduction of level transition and the design of the minimal educational unit can provide a quantifiable and verifiable theoretical method for cross-actor collaboration.

In the future, the success of AI literacy education in university libraries will depend on whether it can achieve balanced unity across three dimensions: at the technological level, it must actively embrace innovative tools while preventing technological worship; at the educational level, it must take into account both the improvement of learning efficiency and the cultivation of critical thinking; and at the cultural level, it must promote technological application while also upholding humanistic values. Only in this way can university libraries become "lighthouses of civilization" in the intelligent era, illuminating the future path toward the coexistence and shared prosperity of knowledge creation and the humanistic spirit.

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Research on AI Literacy Education in University Libraries Driven by Intelligence: Collaborative Mechanism, Practice Model and Implementation Path

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Abstract Artificial intelligence (AI) technology is reshaping the ecological landscape of higher education, and university libraries are facing a strategic opportunity to transform from resource providers into hubs for AI literacy education. Currently, AI literacy education still faces the "last-mile" implementation challenge. This paper systematically explores the practical dilemmas and development paths of AI literacy education in university libraries through model induction and framework construction methods. First, through an investigation of AI literacy education practices in university libraries, it analyzes the bottlenecks existing in current AI literacy education practice, such as uneven resource distribution, poor content articulation, and methodological lag. Second, based on an intelligent education framework underpinned by the PPDCA cycle, a library-led intelligent collaboration mechanism is constructed from three dimensions: data-knowledge conjugation, spatio-temporal folding, and meaning resonance. Finally, the library is reconstructed into a five-in-one collaborative center, comprising the roles of "demand insight, solution architect, scenario builder, value gatekeeper, and system optimizer," which provides a theoretical basis and practical paradigm for promoting AI literacy education on a large scale in universities.

Keywords AI literacy education; University libraries; Intelligence-driven

Note: Figure translations are in progress. See original paper for figures.