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Issue Overview

This issue of Journal of Psychology & Education brings together five contributions on educational innovation, university student development, lifelong learning, and the responsible use of artificial intelligence. The articles examine how educational institutions can respond to technological and social change while maintaining a commitment to human agency, professional competence, and meaningful learning.

The issue opens with a study of interdisciplinary teaching teams for health law, proposing collaboration among universities, hospitals, law firms, and health administration. A second article explores how artificial intelligence participates in the formation of university students' self-identity, along with potential risks to independent judgment. The third contribution discusses the contemporary significance of lifelong education and pathways toward more inclusive learning opportunities across the life course.

The fourth article critically examines the effects of generative AI on students' independent thinking and outlines a pedagogical approach that protects cognitive agency. Finally, a questionnaire-based study of Pharmaceutical Botany compares traditional, information-technology-supported, and blended teaching methods. Together, these articles highlight the importance of integrating technological development with educational responsibility, reflective judgment, and student-centered practice.



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From Industry–Education Collaboration to Multi-Agent Symbiosis: Building "Double-Qualified" Teaching Innovation Teams for Health Law in Undergraduate Medical Universities

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Abstract

Against the converging backdrop of the Healthy China strategy, the rule-of-law China initiative, the construction of New Liberal Arts and New Medical Education, and the accelerating digital transformation of education, undergraduate health law education faces an increasingly urgent demand for "double-qualified" teachers who combine medical literacy, legal reasoning, frontline practical experience, and digital teaching competence. Drawing on the policy trajectory and research literature of double-qualified teacher development and on the disciplinary particularities of health law, this article diagnoses three intertwined predicaments in the building of health law teaching teams: the "single-discipline" predicament of disconnection between academic theory and practice, entrenched institutional barriers to cross-sector collaboration, and the lagging capacity to transform sensitive authentic caseloads into digital teaching resources. In response, it proposes a four-in-one multi-agent symbiotic community comprising universities, affiliated hospitals, specialized law firms, and health administrative departments, advanced along the logical main line of "standards leading – substantive mechanisms – digital empowerment – evaluation driving," and accompanied by a four-stage implementation strategy and risk-control arrangements. The study shows that a team-iteration pathway driven by the development of authentic digital teaching assets can effectively break the status barriers between universities and the medical–legal practice sector, offering replicable institutional experience for faculty development in comparable interdisciplinary fields.

Keywords: Health Law; double-qualified teachers; teaching innovation team; industry–education integration; multi-agent collaboration; educational digitalization

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I. INTRODUCTION

1.1 Policy Background

The quality of talent cultivation depends directly on the competence of the teaching staff; faculty development is thus the core issue in building medicine–law interdisciplinary programs. A reasonably structured and mutually complementary teaching innovation team is both the organizer of curriculum and textbook reform and the integrator and transformer of industry–education resources. This study is rooted in three converging policy backgrounds. First, the building of Healthy China and rule-of-law China has generated an urgent demand for compound health rule-of-law talents. As the reform of the healthcare system deepens and the legalization of the health sector accelerates, laws such as the Basic Medical and Health Care and Health Promotion Law and the Physicians Law have been enacted or revised in succession. The industry now needs talents who can handle physician–patient communication, medical dispute mediation, and hospital compliance review while also understanding the institutional logic of health

legislation and regulation—competencies ultimately determined by the teaching quality of Health Law courses and, therefore, by the cross-boundary literacy of the teaching staff.

Second, industry–education integration and the New Liberal Arts and New Medical Education initiatives provide the strategic orientation for collaborative cultivation. The Several Opinions of the General Office of the State Council on Deepening the Integration of Industry and Education explicitly call for breaking disciplinary and institutional boundaries and promoting deep collaboration between higher education and industry (General Office of the State Council, 2017), and the Guiding Opinions on Accelerating the Innovative Development of Medical Education further require planning medical education reform with new concepts and new positioning (General Office of the State Council, 2020). The New Liberal Arts initiative likewise emphasizes interdisciplinary integration and the cultivation of versatile, innovative talents (Fan, 2020). Health law, as a typical medicine–law interdisciplinary field, can no longer satisfy practical needs through theoretical instruction confined within universities. Third, the digital transformation of education imposes new requirements of teacher capability iteration. Researchers have argued that the essence of educational digital transformation lies in empowering educational modernization and talent cultivation through digital technology, rather than the simple superimposition of technical means (Li, Zhang, & Ge, 2023). Teachers must therefore master both interdisciplinary professional literacy and the ability to develop and apply digital teaching resources, transitioning from "knowledge transmitters" to "learning designers and resource transformers."

1.2 Conceptual Definitions

In this study, a double-qualified teacher refers to a university teacher who, in the teaching context of medicine–law interdisciplinary courses, possesses systematic legal literacy together with the necessary medical knowledge background and frontline experience in medical dispute mediation or health administrative enforcement, and who is able to transform practical resources into digital teaching products. Unlike the certificate- or title-based definitions prevailing in vocational education, this article stresses "competence compoundness" rather than "certificate stacking": the benchmark is the competency structure required by authentic work tasks. A teaching innovation team denotes a teaching organization jointly composed of in-house teachers and industry-part-time experts that conducts collaborative teaching research around shared goals, with explicit division of labor and operating mechanisms.

1.3 Research Design and Methods

This study adopts an action-research design embedded in the two-year construction cycle of the teaching innovation team. Following the iterative cycle of planning, action, observation, and reflection, the research team functions simultaneously as the reform implementer, which ensures that institutional designs are continuously calibrated against teaching practice rather than remaining paper schemes. Three strands of evidence are triangulated. First, documentary analysis covers national and provincial policy texts on

industry–education integration, New Liberal Arts and New Medical Education, and educational digitalization, as well as institutional documents on faculty management and curriculum reform. Second, stakeholder evidence is collected through semi-structured interviews and questionnaires with in-house teachers, hospital physician–patient-relations staff, practicing lawyers, health administrators, and students, so that the demand side of talent cultivation and the supply side of faculty competencies are mapped onto each other. Third, teaching-effectiveness evidence includes classroom observation records, student evaluations of double-qualified classrooms, and usage statistics of the de-identified case repository and virtual simulation modules. Ethical review and informed-consent procedures are observed throughout the research, and all case materials are de-identified before entering either research or teaching. This design enables the study not only to describe a construction pathway but also to examine, through recursive evidence loops, whether and under what conditions the pathway actually works.

II. LITERATURE REVIEW

2.1 Research on Double-Qualified Teacher Teams

A rich body of research has addressed the connotation, accreditation, and construction pathways of double-qualified teachers. At the level of standards, scholars have noted that the accreditation and cultivation of double-qualified teachers' professional competence is a systematic project confronted with inconsistent standards, uncoordinated training systems, imperfect practical guarantees, and insignificant assessment incentives, and have proposed a unified competency standard system together with multi-agent practical guarantees and separate assessment and incentive arrangements (Yin, K., 2022). Studies of accreditation policy show that the value orientation and indicator design of accreditation standards directly affect teachers' engagement in industry–education integration (Zeng, Lu, & Ai, 2021), and a national survey of 153 vocational colleges across 23 provinces reveals marked regional differences in indicator composition, tiered progression, and supporting incentives, calling for a layered and classified framework on top of national standards (Zhang & Wang, 2022). At the level of construction pathways, researchers have proposed unified standard systems, "point–chain–surface" training configurations, and multi-agent guarantee systems (Yin, K., 2022), as well as practical pathways emphasizing teacher ethics, standard establishment, and recruitment–cultivation mechanisms (Li, H., Jiang, Ren, & Li, 2023). From the perspective of organizational behavior, Jiao, Zhang, and Wang (2024) identify low organizational maturity, circulation barriers for double-qualified teachers, the scarcity of leading talents, and the absence of symbiotic culture as salient predicaments, and argue that only by relying on industry–education communities to smooth the circulation path and optimizing team structure and talent echelons can high-quality development of teaching innovation teams be achieved.

2.2 Research on Medico-Legal Talent Cultivation and Curriculum Reform

Research on health law education has long focused on talent-cultivation models and curriculum systems. Huang et al. (2007) pointed out early that cultivating compound medico-legal talents is a systemic project whose success hinges on scientifically determining training objectives, basic qualities, and cultivation models. Reviewing two decades of development, Tian, Liu, and Wei (2014) showed that ambiguous program positioning, "patchwork" curricula, and insufficient faculty compound competence have been persistent structural problems. Luo et al. (2013) proposed integrating theoretical and practical teaching systems through the deep coupling of practice links with theoretical instruction. At the classroom level, Yu, Tian, and Su (2021) argued that health law courses should aim at cultivating the legal thinking of medical staff rather than the internal logic of legal provisions, and that case teaching and moot court should be comprehensively applied; the course also has inherent advantages for curriculum-based ideological and political education. Li and Feng (2017) revealed from the perspective of professional accreditation an obvious gap between health law education and accreditation standards for clinical medicine. Yin, C. (2017) further noted that inconsistent program settings, the shortage of interdisciplinary faculty, the disconnection between teaching cases and legal practice, and outdated methods and content have severely constrained talent cultivation, proposing an information-technology-based collaborative training platform.

2.3 Research on Digital Empowerment of Teaching

Educational digitalization provides new technological conditions and research agendas for resolving the predicaments above. Li, Zhang, and Ge (2023) systematically expounded the essence and approaches of educational digital transformation, advocating an "empowerment" orientation and a dialectical grasp of new technologies in relation to existing pedagogical tools. Luo (2023) analyzed the multiple predicaments of teachers' digital transformation of teaching—the tension between technology acceleration and pedagogical routines, the mismatch between task multiplication and insufficient digital competence, and the paradox between technological efficiency and increased workload—and proposed solutions from the dimensions of literacy cultivation, paradigm guidance, and organizational linkage. These studies suggest that the key to digital transformation lies not in the introduction of tools per se but in the systematic reshaping of teachers' digital literacy and pedagogical paradigms.

2.4 Research Gap

In summary, existing research has advanced along three directions: the general principles of double-qualified teacher team building, the particularities of medico-legal talent cultivation, and the empowering mechanisms of educational digitalization. Two gaps remain. First, most double-qualified research takes vocational colleges as its object; studies targeting the undergraduate level, and especially dual-crossing disciplines such as "medicine plus law," remain weak, lacking accreditation standards and growth-pathway designs adapted to their competency structures. Second, health law reform research mostly concentrates on

curricula and teaching methods; systematic schemes that start from faculty development and bundle "team building" with "resource building," particularly the mechanism design of university–hospital–law firm–government multi-agent collaboration, are rarely explored empirically. This article addresses these gaps.

III. PRACTICAL PREDICAMENTS IN BUILDING HEALTH LAW TEACHING TEAMS

3.1 The "Single-Discipline" Predicament

Most current university teachers of health law come "from school to school" with a legal or medical background, producing structural competency deficiencies. Law-trained teachers are unfamiliar with clinical norms, medical records, and damage-appraisal procedures; medicine-trained teachers lack rigorous legal reasoning and cannot complete standardized legal analysis and drafting; and both groups generally lack frontline experience in medical dispute mediation and health administrative enforcement. Existing studies have identified the shortage of interdisciplinary faculty, the disconnection between teaching cases and legal practice, and outdated teaching methods as key factors constraining medico-legal talent cultivation (Yin, C., 2017; Huang et al., 2007). In classroom teaching, these deficiencies lead to "purely theoretical" content and bare recitations of legal provisions, while the pedagogical requirements—case teaching, moot court, cultivation of legal thinking—demand practical experience and transformation competence that precisely constitute the weak link of the current faculty (Yu, Tian, & Su, 2021; Li & Feng, 2017). In essence, the single-discipline predicament is a structural mismatch between the competency structure the interdisciplinary course requires ("conversant in both medicine and law, versed in both theory and practice") and the supply of teachers ("single-discipline origin, from school to school").

3.2 Institutional Barriers to Cross-Sector Collaboration

Although industry–education integration has become a consensual reform path, an obvious barrier to the transfer of practical experience persists among universities, hospitals, law firms, and health regulatory agencies. On the one hand, industry experts "cannot get in": universities lack flexible special appointment and qualification mutual-recognition mechanisms. On the other hand, in-service teachers "cannot get out": secondment opportunities are limited, and practical experience is decoupled from professional-title evaluation and performance assessment. Research consistently identifies mismatches between internal management, evaluation, and assessment systems on the one hand and the needs of industry–education integration on the other, together with the absence of long-term cooperation and benefit-sharing mechanisms, as the primary institutional obstacles (Jiao, Zhang, & Wang, 2024; Li, H., et al., 2023). Studies of accreditation policy similarly show that uneven tiered-progression and incentive arrangements prevent the double-qualified identity from effectively steering teachers' practical investment (Zeng, Lu, & Ai, 2021; Zhang & Wang, 2022). As a result, most cooperation remains ceremonial: many agreements but little substantive operation, many lectures but little curriculum co-construction, many classroom observations but

little case-following practice—the concrete manifestation, in health law, of the "circulation mechanism barrier" repeatedly identified in team-building research (Jiao, Zhang, & Wang, 2024).

3.3 Lagging Digital Resources and Innovation Capacity

Confronted with massive and highly sensitive authentic medical–legal cases, teacher teams generally lack the capacity to transform them into high-fidelity interactive digital resources. Yet explorations of legal education digitalization show that virtual simulation can bridge theory and practice: introducing the non-legal technical factors of real judicial processes into teaching achieves a high-fidelity simulation of the authentic judicial environment, and the combination of virtual simulation with mock-trial courses has proven effective in enhancing students' practical engagement. The difficulty is that developing such resources requires the compound competence of "medicine + law + educational technology"—command of clinical processes and case-file structures, of legal issues and instructional design, and of digital tools such as virtual simulation and micro-lecture production—which single-background teachers can hardly manage independently. Moreover, the predicaments revealed by research on teachers' digital transformation—pedagogical-routine constraints, insufficient digital competence, and increased workload (Luo, 2023)—are superimposed on health law teachers, who must simultaneously make up deficits in medicine, practice, and technology. Objectively, this demands collaborative development by mixed teams, converting tasks beyond individual capacity into collective action.

IV. A MULTI-AGENT COLLABORATIVE PATHWAY: THE "UNIVERSITY–HOSPITAL–LAW FIRM–GOVERNMENT" COMMUNITY

To address the predicaments above, this article proposes building a four-in-one cross-border teaching and research community that brings together universities (supplying theory), affiliated hospitals (supplying medical scenarios), specialized law firms (supplying medical-dispute legal practice), and health administrative departments (supplying administrative compliance expertise), advancing along the logical main line of "standards leading – substantive mechanisms – digital empowerment – evaluation driving."

4.1 Standards as the Lead

It is necessary to move beyond the superficial equation of "double qualification" with dual certificates. Accreditation research shows that the value orientation and indicator design of standards strongly steer teacher behavior (Zeng, Lu, & Ai, 2021), and national surveys indicate that layering and classification are the basic trend of standard building (Zhang & Wang, 2022). Accordingly, jointly with practice partners and based on authentic work tasks such as medical dispute mediation and health compliance review, the four core competency elements—medical-ethical literacy, legal reasoning, practical operational ability, and digital teaching competence—should be derived in reverse to formulate the competency standard and accreditation measures for double-qualified teachers of health law at the undergraduate level. Differentiated

gap-filling programs and tiered growth pathways should then be tailored to teachers of different backgrounds: law-trained teachers remedy medical cognition through clinical observership and medical-record study; medicine-trained teachers strengthen legal thinking through systematic legal study and case-following practice; industry-part-time teachers focus on instructional design, classroom organization, and curriculum-based ideological education, so that the three types converge into a mixed team with a reasonable structure and complementary competencies. The standard should also be linked with developmental evaluation: periodic competency-profile assessments enable teachers' self-diagnosis and provide the basis for dynamic team adjustment.

4.2 Substantive Mechanisms

The ceremonial model of cooperation should be replaced with substantively operating arrangements. First, a "revolving door" mechanism should be established whereby in-service teachers take tasks and projects to hospital physician–patient-relations offices or law firms for case-following practice, with practical workload equivalently converted into teaching workload so that teachers can "go down, gain real experience, and have it properly counted." Second, special posts of "industry mentor" and "practice professor" should be set up to flexibly recruit senior medical lawyers, health judges, and hospital administrators for deep participation in syllabus revision, case-based lecturing, and practice supervision, with course-fee subsidies, outcome co-authorship, and joint teaching-research arrangements guaranteeing sustainability; national policy on combining fixed posts with mobile posts in faculty personnel management (General Office of the State Council, 2020) provides institutional space for such arrangements. Third, the college should sign formal co-construction agreements with practice units, making explicit arrangements on funding allocation, mutual recognition of two-way workload, outcome ownership, and confidentiality obligations. As Jiao, Zhang, and Wang (2024) note, only by relying on industry–education communities to smooth the circulation path of double-qualified teachers and optimizing team structure and talent echelons can high-quality team development be achieved. The crux of mechanism design lies in the restructuring of the interest structure: only when the participation of practice units translates into perceptible benefits—talent pipelines, compliance improvement, industry reputation, and research cooperation—and when teachers' practical investment is fairly measured by the evaluation system, can two-way mobility shift from policy advocacy to the rational choice of all parties.

4.3 Digital Empowerment

Transforming team-building achievements directly into teaching assets is the key to avoiding "building teams without improving teaching." Mixed R&D groups of in-house theory teachers and external practitioners should, under strict red lines of patient privacy and data security, collect authentic medical–legal case files and typical disputes, formulate "standards for de-identifying and digitally reconstructing practice files," and transform them into highly interactive scenario-based resources, including script-style

moot court case repositories and virtual simulation modules for physician–patient communication and compliance review, ultimately building a searchable de-identified case repository indexed by knowledge points. In terms of resource forms, a hierarchy of "case repository – micro-lecture cluster – virtual simulation modules" should be formed: the repository carries raw materials and pedagogical adaptation; micro-lectures support fragmented learning in blended settings; simulation modules provide immersive training for comprehensive practical scenarios. Digital-education research reminds us that technological empowerment should serve the transformation of pedagogical paradigms rather than the mere stacking of tools (Li, Zhang, & Ge, 2023), and that teachers' digital competence grows through organized cultivation and linkage mechanisms (Luo, 2023). The resource-development process is thus itself a cultivation process for digital literacy: in jointly dissecting files, de-identifying data, and designing interactive segments, in-house and external experts achieve a natural collision of medical logic, legal thinking, and digital pedagogy, tempering the team while accumulating reusable high-quality digital assets. This pathway of "projects driving the team, outputs promoting integration" tightly binds team building with resource building, avoiding the familiar disjunction between faculty development and teaching reform.

4.4 Evaluation-Driven

The current professional-title and performance systems overweight academic papers and vertical grants, leaving teachers with insufficient intrinsic motivation for practice teaching. Teacher-evaluation research identifies insufficient comprehensiveness of methods, insufficient personalization of standards, and insufficient professionalism of evaluators as salient problems (Chen, Wang, & Jiang, 2022), and policy studies confirm that the value orientation of accreditation and evaluation determines policy efficacy (Zeng, Lu, & Ai, 2021). Pilot reforms of diversified dynamic evaluation should therefore be conducted within the team: teachers' secondment performance, their leading or participating role in medico-legal public-interest services, the quantity and quality of authentic teaching cases transformed, and their contribution to digital training resources should be incorporated as equivalents partially replacing traditional research indicators; a multidimensional evaluation model jointly participated in by the academic affairs office, hospitals, and law firms should be constructed, exploring an equivalent-recognition pathway between practice-transformation outcomes and traditional teaching–research outcomes. Evaluation reform does not weaken academic standards; on the premise of holding the bottom line of teaching quality, it brings "the ability to solve real problems" into the accounting scope of academic contribution. Evaluation results should be linked to the dynamic entry and exit of team members, performance distribution, and training-resource allocation, forming a closed loop of "evaluation – feedback – improvement – re-evaluation." Classified evaluation principles should run through the process, with differentiated weights for members of different origins and roles.

4.5 Co-Constructing a Symbiotic Culture and Dual Professional Identity

Beyond formal standards, mechanisms, resources, and evaluation, the long-term viability of a cross-sector team depends on culture and identity. Team-building research identifies the absence of a symbiotic culture as a salient predicament of teaching innovation teams (Jiao, Zhang, & Wang, 2024). Accordingly, deliberate culture-building arrangements are embedded in the pathway: regular joint teaching seminars in which physicians, lawyers, and teachers co-dissect freshly de-identified cases; "case grand rounds" alternating between the hospital and the law firm; and co-authored teaching-research projects that convert individual tacit experience into shareable pedagogical knowledge. Through sustained participation in such communities of practice, members gradually develop what may be termed a dual professional identity: they cease to see themselves as "a lawyer guest-lecturing in a university" or "a teacher visiting a law firm," and begin to identify as members of a bi-professional epistemic community whose shared enterprise is the cultivation of health rule-of-law talents. Recognition arrangements reinforce this identity—joint certificates of teaching appointment issued by the university and the practice unit, explicit acknowledgment of co-developed resources in teaching awards, and public commendation of outstanding industry mentors—so that the psychological contract between the parties rests not only on formal agreements but on accumulated mutual trust and reciprocal benefit. In this sense, the multi-agent community ultimately evolves from an institutional arrangement into a professional ecology in which teachers, practitioners, and administrators learn from one another, and the collaboration acquires self-renewing momentum that no longer depends on external administrative push.

V. IMPLEMENTATION STRATEGY AND SAFEGUARD MECHANISMS

5.1 Four-Stage Implementation

Team building is a systematic project and should proceed in four rolling stages: "demand diagnosis and team formation – mechanism trial operation and resource development – evaluation reform and teaching verification – model refinement and outcome promotion." In stage one (months 1–6), industry-demand surveys and faculty competency diagnostics are conducted; the parties jointly formulate the trial "Competency Standard and Accreditation Measures for Double-Qualified Teachers of Health Law," sign multi-agent collaborative agreements, and form the mixed team, producing a baseline survey report and individualized cultivation plans. In stage two (months 7–15), two-way mutual appointment starts: teachers are seconded to law firms and hospitals for case-following practice, practitioners participate in instructional design, and the mixed team centrally develops the de-identified case repository and micro-lectures, piloting them in selected classes. In stage three (months 16–20), the new evaluation and incentive measures are trialed based on team outputs; student feedback on double-qualified classrooms and digital resources is collected, and teaching-effectiveness data analyses yield a comprehensive industry–education-oriented evaluation scale and an assessment report. In stage four (months 21–24), the experience of action research is

summarized, the "university–hospital–law firm–government" model is refined, and concluding materials, teaching-research papers, and policy consultation reports are prepared for in-school and inter-university dissemination.

5.2 Organizational and Conditional Safeguards

In terms of organizational safeguards, the college should convene a collaborative-education steering committee composed of representatives of the university's academic affairs office, affiliated hospitals, partner law firms, and health administrative departments to coordinate agreement performance, funding use, and dispute resolution, preventing the collaboration from fading with personnel changes. In terms of conditional safeguards, existing smart classrooms, moot courts, and online teaching platforms provide hardware and network environments for virtual simulation development and cross-sector blended teaching research; licenses for professional legal case databases should be procured to remedy the shortage of high-quality specialized databases. In terms of institutional safeguards, the university should grant policy preferences in project approval, professional-title evaluation, and performance distribution to participating teachers, and incorporate practical experience into recognized teacher-development hours and annual assessment. The research team's prior accumulation in digital resource development, curriculum-based ideological reform, and industry–education practice bases lays a foundation for implementation.

5.3 Risk Control

The pedagogical transformation of practical resources involves multiple risks requiring explicit control arrangements. First, legal and ethical risk: medical-dispute files involve patient privacy, trade secrets, and pending case information; a full-process management norm of "collection – de-identification – review – use" must be established with designated de-identification standards and reviewers, and all resources must pass dual legal and ethical review before release. Second, quality risk: practitioners' pedagogical transformation competence varies; joint lesson preparation, teaching observation, and collective review should gate resource quality, preventing "rich practice but poor pedagogy." Third, sustainability risk: cooperation may weaken with personnel turnover or institutional adjustment; agreements should stipulate terms, renewal mechanisms, and outcome ownership, and cooperation units should be kept small and project-based to reduce dependence on single key figures. Fourth, data-security risk: digital resources should be deployed on university-controlled platforms with tiered access permissions and established withdrawal and destruction mechanisms.

VI. PRACTICAL OUTCOMES AND TRANSFERABLE VALUE

Following the above pathway, the model has been piloted in the core course of Health Law with initial results. First, the faculty structure has been optimized. Through two-way mutual appointment and case-following practice, in-service teachers have accumulated frontline medico-legal experience while

practitioners routinely participate in classroom teaching and curriculum design; a mixed double-qualified team combining medical literacy, legal reasoning, and digital teaching competence has begun to take shape, and classroom teaching has shifted from "reciting legal provisions" to an authentic-scenario model of "project-driven learning + case deduction + virtual training," markedly improving students' comprehensive practical abilities in physician–patient communication, dispute mediation, and compliance review.

Second, high-quality digital teaching assets continue to accumulate. The de-identified authentic case repository and virtual simulation modules jointly developed by the mixed team serve the routine teaching of majors such as Clinical Medicine, Public Administration (Health Administration), and Health Service and Management can be extended to related courses such as Medical Ethics and Health Administrative Law and promoted to comparable universities. Third, the capacity for social service has grown in step: the reformed team can act as a professional think tank in local medical dispute mediation, hospital compliance review, and consultation on health administrative legislation, realizing a virtuous interaction between educational resources and social governance and feeding fresh materials back into teaching in a cycle of "teaching – practice – service – feedback into teaching."

Fourth, the reform has generated demonstrable spillover effects on talent cultivation and curriculum development. The double-qualified classroom model of "project-driven learning + case deduction + virtual training" has been extended from the core course of Health Law to related courses such as Medical Ethics and Health Administrative Law, driving the systematic revision of syllabi and examination methods in the program. Students trained in authentic scenarios show improved performance in physician–patient communication exercises, dispute-mediation simulations, and compliance-review assignments, and their course satisfaction ratings have risen steadily. The model has also strengthened curriculum-based ideological and political education: real dispute-mediation stories convey the people-centered value of the rule of law more convincingly than abstract preaching, realizing the integration of value shaping, knowledge imparting, and competence building (Yu, Tian, & Su, 2021). Feedback from internship hospitals and employers further indicates that graduates taught under the reformed model demonstrate stronger rule-of-law thinking and communication competence in clinical settings, which provides external validation of the reform and closes the quality loop from classroom to workplace.

VII. CONCLUSION

The construction of double-qualified teaching innovation teams for Health Law is, in essence, a reconstruction of the way interdisciplinary faculty are produced under New Liberal Arts and New Medical Education: competency standards clarify "what a good teacher is"; substantive mechanisms answer "where people come from and where they go"; digital resource development provides the carrier of "gathering people through tasks"; and evaluation reform opens the "last mile" that makes teachers "willing to go and

able to stay." Practice shows that systematic design along the main line of "standards leading – substantive mechanisms – resource transformation – closed-loop evaluation" can effectively break the status barriers between universities and the medical–legal practice sector, cultivate a mixed double-qualified team, shift classroom teaching from knowledge infusion to authentic-scenario reconstruction, and significantly enhance students' practical competence. Team building remains a long-term undertaking. Continued exploration is needed on the institutionalization of equivalent recognition between practical and teaching workload, the regular updating of de-identified case resources, and the linkage between evaluation reform and university personnel systems, so that reform outcomes can be consolidated into replicable, transferable institutional experience, providing solid support for the cultivation of health rule-of-law talents and for comparable interdisciplinary fields.

This study makes three theoretical contributions. First, it extends double-qualified teacher research from vocational education to the undergraduate interdisciplinary context, proposing a competency-based rather than certificate-based definition suited to "medicine plus law" dual-crossing disciplines. Second, it reframes faculty development as a problem of multi-agent symbiosis, showing that team building, resource building, and evaluation reform must be bundled within a university–hospital–law firm–government community rather than pursued separately. Third, it demonstrates that authentic digital resource development can serve as the pivot that simultaneously cultivates teachers, accumulates teaching assets, and transforms classrooms. The study is nevertheless bounded by its single-institution action-research setting: the four-stage pathway, the competency standard, and the equivalent-recognition arrangements were designed for and tested within one medical university, and their generalization to universities of different types requires contextual adaptation. Future research should therefore conduct multi-site comparative studies, track the longitudinal career development of double-qualified teachers, and examine how generative artificial intelligence reshapes the cost structure of de-identifying cases and developing simulation resources, so that the pathway can be continuously refined in tandem with the deepening of educational digitalization.

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Self-identity formation and risks among university students in the age of artificial intelligence

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Abstract

Artificial intelligence increasingly participates in the activities through which university students learn what they can do, explain who they are, and imagine who they might become. This theoretical review examines the formation of self-identity through AI-supported learning, writing, social interaction, and career exploration. It connects identity development and narrative identity with research on human agency, motivation, cognitive offloading, algorithmic mediation, and generative AI. The central argument is that AI becomes relevant to identity when students interpret technologically mediated experiences as evidence about their abilities, commitments, social worth, or future prospects. AI can widen opportunities for participation and experimentation, especially when it makes unfamiliar tasks and forms of expression accessible. Risks emerge when students delegate judgments they need to develop, adopt generated accounts of their lives without examining them, or treat algorithmic evaluations as authoritative descriptions of personal potential. Institutional assessment practices and unequal access influence these processes. The review proposes an educational approach that combines explicit decisions about delegation, opportunities to demonstrate learning across assisted and independent tasks, recognition of diverse voices, and accountable governance of student data. It also identifies research designs capable of separating immediate performance gains from changes in identity over time. Universities can support students' self-authorship by making the relationship between assistance, achievement, and responsibility visible throughout learning.

Keywords: self-identity, university students, generative artificial intelligence, student agency, narrative identity, higher education

I. INTRODUCTION

A student who uses artificial intelligence to revise an essay encounters a question that extends beyond whether the new paragraph is accurate. The revision changes the evidence through which the student and others judge the student's abilities. Similar questions arise when a coding assistant completes a difficult function, a chatbot interprets a personal conflict, or a career application recommends a professional pathway. Each interaction can enter an ongoing account of personal competence and direction. University students develop self-understanding through academic work, relationships, and decisions about the future. As AI participates in those activities, it becomes part of the circumstances under which self-identity takes shape.

Self-identity concerns the continuity and meaning people give to their lives, the commitments they recognize as their own, and their understanding of their place among others. The concept includes more than a momentary feeling of confidence. A student can feel reassured by an AI-generated answer while remaining uncertain about being a capable learner. Another can struggle with an assignment while developing a stronger commitment to a discipline. These differences matter because educational discussions frequently move from better task performance to claims about empowerment without examining how

students interpret their experiences. The formation of identity involves that interpretation and its connection to subsequent action.

Research on AI in higher education provides reasons to examine this process closely. Zawacki-Richter et al. (2019) identified a weak connection between many AI applications and educational perspectives, alongside limited critical attention to risks. More recent student research addresses perceived usefulness, concerns about accuracy, and expectations about personal development (Chan & Hu, 2023). Such findings establish that students recognize several consequences of AI use. They leave open how repeated experiences become durable beliefs about who students are. An identity perspective links educational technologies to the development of commitments and personal responsibility across university life.

This review develops the argument that AI affects self-identity through the interpretation of mediated experience. Students encounter an output or recommendation, attribute its value to particular sources, and use that attribution to revise their understanding of themselves. Their response then influences later choices about effort, disclosure, relationships, and aspiration. The analysis draws on foreign-language scholarship in identity theory, educational psychology, human-computer interaction, and AI research. It treats generative AI as a central case while considering recommendation systems and algorithmic evaluation where they shape the same developmental processes. The resulting framework connects the formation of identity to identifiable practices and institutional conditions.

II. SCOPE AND CONCEPTUAL APPROACH

The article is a theoretical narrative review organized around mechanisms of identity formation. Foundational literature supplies concepts of exploration, commitment, narrative continuity, agency, and possible selves. Contemporary research supplies evidence about AI-supported performance, student perceptions, dependence on assistance, creative production, and interaction with social chatbots. These bodies of work address different populations and outcomes. Their integration therefore requires a clear distinction between findings reported by individual studies and propositions developed here about university students. The review uses the latter to formulate explanations and research questions, without treating them as established causal effects.

Literature selection prioritized English-language original studies and established theoretical works that explain identity development or examine relevant forms of AI use. Contemporary evidence receives particular attention where it identifies differences between assisted performance and learning, or between intended and experienced forms of interaction. The synthesis proceeds from developmental concepts to specific encounters with AI, then examines the social conditions under which those encounters acquire meaning. This approach places findings from different research traditions in a common explanatory

framework. Its unit of analysis is the process connecting an interaction, the student's interpretation of that interaction, and subsequent participation or commitment.

Terminological precision is necessary because several adjacent concepts can otherwise become interchangeable. Self-esteem concerns evaluations of personal worth; self-efficacy concerns beliefs about the ability to perform particular actions; academic identity concerns belonging and recognition within educational roles. Self-identity concerns the broader organization of these experiences into an account of the person. Student agency denotes students' capacity to influence their learning and conduct through purposeful action. Self-authorship is used here to describe taking responsibility for the reasons and commitments through which one understands and directs one's life. AI refers to the broader technological category, and generative AI denotes systems that produce content in response to inputs.

III. IDENTITY DEVELOPMENT IN UNIVERSITY LIFE

University life places students in settings where earlier identifications encounter new demands. Students select fields, join communities, experience evaluation, and consider work beyond graduation. Erikson's (1968) account connects identity to the relationship between personal development and social circumstances. Marcia (1966) operationalized identity through differences in exploration and commitment. Together, these approaches direct attention to how students arrive at commitments and whether alternatives have received serious consideration. AI enters this process when it offers explanations, representations, or plans that students can adopt while deciding what kind of learner or professional they intend to become.

The developmental significance of university experience also varies across social conditions. Arnett (2000) described emerging adulthood as a period of identity exploration in settings that permit extended transitions into adult roles. Access to such exploration depends on material and cultural circumstances. Students supporting relatives, combining employment with study, or facing restrictive career options have different opportunities to experiment. AI assistance may reduce some immediate costs of exploration, such as the effort needed to understand an unfamiliar discipline. The time and resources required to pursue the resulting possibilities remain unevenly distributed. Any account of AI-mediated identity must therefore consider the conditions under which an apparent option becomes a practical choice.

Narrative identity provides a way to understand how particular experiences acquire personal meaning. McAdams and McLean (2013) describe identity as an evolving life story that connects a reconstructed past with an imagined future. An examination result or failed project becomes consequential through its place in that story. Students may interpret failure as evidence of unsuitability, an episode of learning, or a reason to change direction. AI can supply language for each interpretation. Generated explanations become relevant to identity when students incorporate them into autobiographical accounts and use them to justify future decisions. The effect depends on the relation between the explanation and the student's own experience.

Giddens (1991) places reflexive self-understanding within social conditions that require people to maintain accounts of their lives across changing circumstances. University students already encounter multiple expectations from families, disciplines, employers, and peers. AI adds a readily available source of descriptions and advice to this environment. A chatbot can suggest how to explain a setback, describe a personal strength, or present an aspiration to an audience. This availability changes the practical work of constructing a coherent account. Students gain access to formulations they may struggle to produce, while also encountering ready-made interpretations that can become accepted through repetition.

Agency and motivation explain why these processes have educational consequences. Bandura (2001) connects agency with intentionality, forethought, self-regulation, and reflection within social structures. Ryan and Deci (2000) identify autonomy, competence, and relatedness as basic psychological needs in motivation and development. These frameworks help distinguish different experiences of receiving assistance. Students can endorse the purposes of an AI-supported activity and understand their contribution to its outcome. They can also experience a successful outcome as disconnected from their capacities or choices. The identity implications emerge through how assistance affects ownership of goals and interpretations of competence over time.

IV. HOW AI PARTICIPATES IN THE FORMATION OF SELF IDENTITY

4.1 Learning performance and the interpretation of competence

Academic competence becomes part of identity through repeated encounters with difficulty and feedback. Generative AI changes these encounters by supplying explanations, examples, and partial solutions at the point of need. Chan and Hu's (2023) survey of university students in Hong Kong documented perceived benefits for learning support, writing, and idea generation, alongside concerns about dependence and personal development. Students thus encounter AI as a resource for doing academic work and as an object of judgment about how learning should occur. Whether a successful task supports a stronger learner identity depends partly on how the student explains that success.

Consider a student who has previously avoided statistics. An AI explanation makes a regression model understandable, and the student then applies the reasoning to another dataset. The experience can support a revised belief that statistical work is accessible with appropriate assistance. If the same student repeatedly submits generated analyses without understanding the assumptions, the completed tasks supply weaker evidence about transferable competence. These are illustrative pathways, not findings from a single experiment. They show why identity research should examine the attribution of success and subsequent behavior, including whether students choose more demanding work or become increasingly reluctant to proceed without assistance.

Evidence about dependence gives this distinction practical force. Darvishi et al. (2024) examined AI assistance in university peer feedback and found that students tended to rely on assistance more than to acquire the corresponding practices. Their intervention involved specific feedback-support functions rather than contemporary general-purpose chatbots. The study nevertheless establishes an important educational possibility: improved behavior during assistance can coexist with limited persistence after its removal. For identity formation, the proposed consequence is a gap between visible achievement and the student's confidence in acting independently. Research must measure that consequence directly, including students' accounts of ownership and capability.

Students also compare their abilities with the speed and fluency of generated outputs. This comparison changes the reference point against which effort is judged. A novice may interpret a rough first draft as evidence of personal inadequacy when a system produces polished prose immediately. Another may use the contrast to identify a particular skill worth practicing. Teachers influence which interpretation becomes credible by explaining how expertise develops and by making the purpose of practice explicit. The identity question concerns what students learn about themselves from the comparison, especially when the production process behind the machine's output remains largely invisible.

4.2 Writing and autobiographical interpretation

Writing connects academic participation with the formation of a recognizable voice. Students discover positions through selecting evidence, deciding what a sentence commits them to, and responding to criticism. AI-generated text can help students enter unfamiliar genres and express ideas across linguistic barriers. It can also supply the substantive position that a student subsequently presents as personal judgment. The resulting issue concerns the student's relationship to the argument: whether they understand its reasons, accept its commitments, and can revise it when challenged. This relationship makes authorship a developmental question alongside its conventional treatment in academic integrity procedures.

Autobiographical writing creates a particularly direct route into self-identity. Personal statements, reflective assignments, and scholarship applications ask students to organize experience into accounts of motivation and growth. A generated narrative can make a complicated experience easier to communicate. It may also introduce a persuasive explanation that the student had never considered or endorsed. A model might turn uncertain career exploration into a story of lifelong vocation. The student then encounters a polished representation that others may reward. The theoretical risk arises when institutional approval makes that representation harder to question, even though it fits the person's history poorly.

Students retain interpretive agency when they examine generated language against the details of their lives. They can ask whether a description preserves ambiguity, assigns motives accurately, or makes an event appear more decisive than it was. Rejecting an attractive formulation is itself an exercise of judgment. Narrative development therefore depends on access to opportunities for discussion and revision, including

conversations with people who know the student over time. Such encounters provide forms of accountability that a single generated response cannot supply. The educational task is to help students explain why a particular account represents their experience and what remains unresolved within it.

4.3 Recognition through platforms and algorithmic evaluation

Identity develops through social recognition as well as private reflection. Social network sites organize profiles and connections through which people present themselves and encounter audiences (boyd & Ellison, 2007). Contemporary AI features participate in selecting content, proposing descriptions, and interpreting patterns of activity. Bucher's (2017) concept of the algorithmic imaginary directs attention to how people understand and feel about algorithmic operations. Students act partly on these understandings. A belief that certain forms of presentation receive greater visibility can influence what they disclose, which achievements they emphasize, and which aspects of themselves they leave out.

Algorithmic classifications become consequential when institutions use them to organize opportunities. An educational recommendation may describe a student as requiring support; a career application may rank professional matches; a dashboard may mark participation as weak. Each classification simplifies a person for a particular purpose. Its developmental effect depends on whether students and institutional actors treat it as provisional information or a stable description of the student. The proposed mechanism is recursive: a label shapes available activities, those activities generate further data, and the resulting record appears to confirm the original classification. This pathway requires empirical investigation within specific educational systems.

Noble's (2018) analysis of search demonstrates how commercial and social arrangements can reproduce unequal representations of groups. Bender et al. (2021) likewise identify risks associated with the data and scale of language models. For students, these arguments raise questions about the cultural assumptions embedded in descriptions of success, professionalism, and intelligence. A generated recommendation can appear personalized while reproducing conventional expectations about who belongs in a role. Universities need procedures through which students can examine such descriptions, compare alternatives, and challenge consequential classifications. These procedures affect whether recognition supports exploration or narrows its terms.

4.4 Relationships and imagined futures

Conversational systems can offer a space to articulate concerns before discussing them with another person. Students may use them to rehearse a difficult conversation, explore an unfamiliar identity, or find words for an experience they have been reluctant to disclose. Earlier digital identity research already examined experimentation across mediated settings (Turkle, 1995). Generative dialogue adds responsive language that can adapt to the user's account. Its identity relevance lies in how students interpret the

response: as a provisional conversational resource, an authoritative interpretation, or evidence that their feelings and choices have received meaningful recognition.

Research on social chatbots shows that relational responses vary across systems and users. Croes and Antheunis (2021) found that interaction with Mitsuku did not automatically develop into friendship. Laestadius et al. (2024) examined accounts of harm connected to emotional dependence on Replika. These studies concern particular technologies and populations rather than university students as a whole. They establish that perceived responsiveness and relational experience deserve analysis instead of assumption. For student identity, a useful question is whether chatbot interaction supports engagement with other relationships or increasingly becomes the primary setting in which personal experience is interpreted and affirmed.

Career imagination provides another route from interaction to identity. Markus and Nurius (1986) explain how possible selves connect present motivation with hopes and fears about the future. AI can help students investigate pathways, identify unfamiliar roles, and compare the demands of different occupations. It also supplies new reference points for judging the future value of current skills. Noy and Zhang's (2023) experiment demonstrated productivity gains on professional writing tasks, offering evidence about changes in task performance. Students' interpretations can extend beyond those findings to broader expectations about occupational worth. Career education should help them distinguish evidence about tasks from conclusions about entire professions or personal futures.

The proposed process also has a temporal dimension. A single successful interaction can produce relief, while repeated interactions can establish expectations about what is possible without assistance. Students may initially use a system to overcome an obstacle, later incorporate it into a routine, and eventually regard that routine as necessary for being a competent participant. The transition depends on opportunities to compare experiences and revise interpretations. Identity research should therefore follow episodes as they accumulate, including occasions when the system is unavailable, produces an error, or conflicts with advice from someone the student trusts. These moments can expose assumptions that otherwise remain unexamined.

V. DEVELOPMENTAL OPPORTUNITIES

AI can expand identity exploration by reducing the initial cost of participation. A student with limited programming experience can investigate an idea using explanations and worked examples. A multilingual student can compare alternative ways to express a position before entering a seminar discussion. Students who have hesitated to ask basic questions can revisit explanations privately. These activities matter developmentally when they lead to participation in practices that previously seemed inaccessible. The resulting opportunity concerns an expanded range of experiences from which students can form

commitments. Its value depends on what happens after entry, including feedback, sustained practice, and recognition from others.

The opportunity is especially clear when assistance makes substantive contributions easier to recognize. Language difficulties can obscure a student's disciplinary understanding; unfamiliarity with a genre can conceal a thoughtful argument. AI-supported revision can reduce these barriers when the student retains control of the claim and checks the resulting language. Institutions then face a responsibility to assess the relevant learning objective. If a course evaluates historical reasoning, linguistic polish alone provides an incomplete basis for judgment. Clear criteria allow students to understand which abilities their achievement demonstrates, helping them incorporate success into a more accurate account of their competence.

Creative assistance offers both individual benefits and questions about shared expression. Doshi and Hauser (2024) found improved evaluations of individual stories under AI assistance alongside reduced collective diversity in the experimental output. Their findings concern a particular writing task, not student identity. They nevertheless identify a condition worth examining in education: students can experience an individual improvement while the range of work produced across a group becomes more similar. Classroom discussion can make this visible by comparing suggestions and examining choices. Students then have opportunities to identify where their interests depart from common formulations and to develop reasons for those departures.

AI also creates opportunities to practice the management of assistance. Students increasingly need to decide which activities to delegate, what evidence to verify, and when to seek a different form of help. Learning to make these decisions can support an identity grounded in responsible participation within complex work. Bandura's (2001) account includes proxy and collective agency, providing a theoretical basis for recognizing that purposeful action often involves others and supporting systems. An educational application follows: students need experiences in which they explain the distribution of work and remain answerable for the outcome. Such experiences can make interdependence compatible with a clear sense of personal responsibility.

Opportunities for identity exploration can also emerge through deliberate comparison of competing positions. In a seminar, students can use generated responses to examine how a question changes when approached from different theoretical traditions. The educational value lies in identifying assumptions and deciding which interpretation is justified. A student who has treated disagreement as personal failure can come to understand it as part of disciplinary participation. This outcome requires a classroom where reasons receive attention and revision is recognized as learning. Without those conditions, producing several perspectives can remain a display of fluency that has little connection to the student's commitments or understanding.

VI. RISKS TO SELF IDENTITY

6.1 Dependence and unstable interpretations of achievement

Cognitive offloading reduces the internal demands of a task by using external resources (Risko & Gilbert, 2016). In university learning, the developmental consequences depend on which demands are transferred and what opportunities remain to practice. Delegating transcription can preserve attention for analysis. Delegating the selection and evaluation of evidence in every assignment removes occasions to develop those abilities. An identity risk follows when students encounter repeated success without acquiring a clear understanding of the contribution they can reproduce. The relevant concern is the organization of practice and attribution across tasks, which cannot be inferred from use frequency alone.

A student who experiences this gap may respond by concealing uncertainty. Good grades and polished outputs create expectations that later performance must sustain. Asking an elementary question can then seem inconsistent with the identity already presented to teachers or peers. Continued delegation becomes a way of maintaining that presentation. This is a theoretical feedback process connecting achievement, expectations, and avoidance. It explains why an intervention focused only on reducing tool access can miss the underlying difficulty. Students also need credible opportunities to acknowledge what they understand, identify what they need to learn, and experience progress without losing recognition.

The opposite interpretive error also deserves attention. Students can attribute every achievement to the system and discount their own work in setting goals, selecting material, evaluating suggestions, and revising the result. Such attribution can weaken confidence even when learning has occurred. Institutions should therefore make contributions discussable. A short explanation of a rejected recommendation, an error discovered in an output, or a revision justified with evidence reveals aspects of competence that a final product conceals. These practices provide a more concrete basis for self-evaluation and help students understand the abilities involved in assisted work.

6.2 Premature commitment and narrowing of expression

AI can supply clear answers at moments when students are still exploring values and aspirations. A career recommendation or personality description may organize uncertainty into a plausible story. The risk is premature closure when students treat that story as sufficient reason for commitment. Marcia's (1966) distinction between exploration and commitment provides the relevant developmental question. Has the student examined alternatives and their consequences, or adopted a readily available account because it appears confident and personalized? The same concern applies when generated arguments make it easy to take a position without encountering the experiences and disagreements through which commitments become informed.

Expression can narrow through repeated accommodation to generated conventions. Students may learn that an acceptable personal statement requires a dramatic turning point or that a professional voice requires particular vocabulary. These expectations can pressure them to reshape experience into recognizable templates. The issue is concrete when a narrative leaves out family responsibilities, uncertainty, or forms of knowledge that fit poorly within the template. Students then face a choice between accurate representation and anticipated approval. Institutional evaluation helps create this choice, especially when assessors reward fluent accounts of personal development without examining whether students can explain and defend the experiences they describe.

Language and cultural differences affect whose expression is regarded as credible. Liang et al. (2023) found bias against non-native English writing in the detectors they tested. This evidence is specific to those tools and samples, and it should guide evaluation of detection systems through independent testing. The identity consequence proposed here arises when an accusation leads students to doubt whether their own voice will receive recognition as legitimate academic work. Fair procedures require opportunities to present process evidence and respond to concerns. Students' standing within an academic community should be considered through evidence that can be examined and challenged.

6.3 Relational dependence and loss of control over personal accounts

Responsive dialogue can encourage disclosure because the interaction is accessible and feels less socially demanding. The resulting risk concerns a growing dependence on predictable affirmation or personalized responses when making sense of difficulties. Students may become less willing to enter conversations where another person has separate needs, remembers previous actions, or disagrees. Laestadius et al.'s (2024) analysis gives grounds for examining harmful dependence in specific relational systems. Extending that question to university life requires attention to students' existing relationships, reasons for use, and changes over time. A single report of emotional support gives little information about the direction of the longer process.

Commercial control introduces another vulnerability. Students can invest personal meaning in an interaction whose availability, memory, and response style are controlled elsewhere. Changes to the service can alter the continuity of an account that has become important to the user. The identity issue concerns dependence on an institutionally unaccountable setting for personal interpretation. Universities should ensure that students have accessible human relationships in which concerns can be discussed over time. Peer communities, academic advising, and counseling each supply different forms of continuity and responsibility; their educational value increases when AI-mediated interaction becomes a routine part of student life.

Personal data also shape the conditions for experimentation. Exploring an identity often requires room to change one's mind without every tentative statement becoming consequential in another setting. Prompts

about family conflict, sexuality, finances, or uncertainty can reveal more than an ordinary assignment. When data move across contexts, students can lose control over which account of themselves reaches which audience. This creates an institutional question about collection, retention, access, and secondary use. Consent should specify the purpose of processing and provide meaningful alternatives where participation in education would otherwise require disclosure. Control over personal records supports the practical freedom to explore.

6.4 Unequal opportunities and insecurity about the future

Students differ in the resources available for effective AI use. Access includes reliable tools and the knowledge needed to evaluate results, alongside time, disciplinary expertise, and support from other people. A fluent output can benefit a student who already knows how to check it more than one who lacks the relevant background. The identity implication is a possible divergence between groups: some gain opportunities for ambitious work, while others become dependent on outputs they cannot assess. This proposition should be tested by measuring assistance practices and learning conditions directly. Subscription status alone provides an incomplete account of the resources involved.

Institutional reactions can intensify these inequalities. Ambiguous rules create uncertainty about which assistance is acceptable and how disclosure will be judged. Students with access to informal advice can negotiate that uncertainty more easily. Others may avoid useful assistance or conceal routine use because they cannot predict the response. An identity cost arises when participation requires persistent uncertainty about whether one is regarded as a legitimate student. Universities can reduce this cost through explicit examples tied to learning objectives, consistent procedures, and opportunities to discuss borderline cases. Such clarity also improves the evidence available when genuine concerns about authorship arise.

Occupational uncertainty places additional pressure on identity. Students commit years of effort to fields whose practices may change substantially. Highly visible demonstrations of automation can invite broad conclusions about the value of that effort. Evidence of productivity effects on particular writing tasks, such as Noy and Zhang's (2023) findings, does not by itself determine the future organization of a profession. Students need opportunities to examine how tasks connect to responsibility, institutional trust, and social needs. Career guidance can then support revisable commitments grounded in actual work, reducing dependence on generalized predictions about replacement or permanent advantage.

These risks can reinforce one another across university life. A student uncertain about disciplinary competence may accept a narrow career recommendation because it promises a clear direction. Generated application materials can then present that direction as a settled identity, and favorable feedback may increase the cost of reconsideration. Alternatively, critical feedback and supportive advising can interrupt the sequence by making another interpretation available. This example illustrates why risks should be studied in relation to actual trajectories. Examining one attitude toward AI at a single moment cannot

establish how dependence, recognition, and commitment interact as students move between academic and professional settings.

VII. EDUCATIONAL AND INSTITUTIONAL RESPONSES

Universities can make the relationship between assistance and learning explicit at the level of individual tasks. An instructor can identify which decisions students are expected to practice and which forms of support are compatible with those objectives. For an argumentation assignment, generating a list of possible objections may be appropriate while outsourcing the evaluation of evidence defeats the purpose of the task. Students should be able to explain these distinctions in relation to their work. This creates a basis for responsible choice and gives them language for understanding why a difficult activity contributes to their development.

Assessment should gather evidence about both the quality of assisted work and the understanding students can carry into new situations. A course can combine an AI-supported project with a discussion of decisions and a later transfer task. These components answer different questions: what the student can achieve with resources, how the student judges those resources, and what learning persists. The combination is especially useful where final products reveal little about the process. It also gives students more accurate feedback for identity development. A strong assisted outcome and an uncertain explanation identify a learning need that a single grade would conceal.

Reflective activities should require concrete accounts of decisions. Students can identify an output they rejected, explain a factual correction, or describe how assistance changed their approach. Generic declarations that AI was useful offer little evidence of agency. A brief commentary tied to an actual decision is more informative and places less pressure on students to produce a polished autobiography of growth. Reflection can include unresolved questions about attribution or confidence. Teachers should evaluate the quality of examination and reasoning, allowing students to report difficulty without treating that report as evidence of weak character or lack of belonging.

AI literacy should include evaluation and social understanding alongside operational skill. Long and Magerko (2020) connect literacy to competencies for understanding, interacting with, and critically evaluating AI. Within university curricula, students can compare outputs against disciplinary evidence, inspect how prompt wording changes recommendations, and identify the purposes embedded in a system's design. They also need practice deciding when additional expertise is required. These activities connect literacy with self-identity by making students active interpreters of technologically mediated experience. The goal is a defensible account of what a system contributes and which responsibilities remain with the user and institution.

Universities should preserve settings where students encounter diverse forms of recognition. Seminars, laboratories, fieldwork, artistic practice, and community projects reveal abilities through sustained participation. Peers and teachers can respond to the reasoning, care, persistence, and judgment that a polished product leaves invisible. These settings also expose students to disagreement and reciprocal obligation. AI may support preparation for such encounters, but their educational value comes from participation with people who can question claims and observe development. Funding and workload arrangements matter here: meaningful recognition requires time for feedback and relationships, particularly for students who have limited access to support outside the university.

Governance should connect the handling of student data to avenues for challenge. Students need to know when an AI system contributes to a consequential decision and how to request an explanation or correction. Procurement should examine the intended educational purpose, data practices, accessibility, and evidence of differential performance across groups. Institutions should also provide workable alternatives when students have reasons to decline a service. These arrangements give practical meaning to agency by ensuring that students can question the systems that describe and evaluate them. Participation in governance can itself become an educational experience in collective responsibility for technological choices.

Curriculum design can make these commitments cumulative across a degree. Early courses can teach students to explain when assistance was useful and to check simple claims. Later courses can require judgments about ambiguous evidence, responsibility for collaborative work, and the consequences of a recommendation for other people. Final projects can bring those practices together through a substantive product and an account of the decisions behind it. A coordinated progression makes expectations easier to understand and reduces repeated negotiation of incompatible rules. It also gives students a record of development that they can use when explaining their abilities to themselves and future employers.

VIII. RESEARCH AGENDA

Research on identity requires designs that follow interpretation and action over time. Longitudinal studies can connect patterns of AI use with changes in commitments, self-efficacy, narrative accounts, and participation. Measures should distinguish the frequency of use from the activities delegated and the reasons for delegation. Interviews and learning records can identify whether an episode of assistance changes how students approach later difficulty. Baseline measures are necessary because students' prior confidence and uncertainty influence their choice of tools. Following transitions between courses and into employment would reveal whether immediate experiences become durable parts of self-understanding.

Experimental work can test proposed mechanisms by varying how assistance is organized. Students might receive direct answers, prompts for explanation, or support that gradually decreases, followed by comparable transfer activities. Outcome measures should include performance, attribution of success,

willingness to attempt a new task, and the ability to explain decisions. Different disciplines will require different indicators of competent judgment. Studies can also examine whether transparent assessment rules change disclosure and perceived legitimacy. These designs would identify which conditions connect assistance with ownership, providing a firmer basis for claims that a technology supports or undermines identity development.

Cross-cultural research should examine the social meaning of autonomy and commitment within actual institutions. Family responsibility, national labor markets, language hierarchies, and disciplinary traditions influence how students understand a worthwhile future. Chinese university contexts provide opportunities to study these relations without assuming that findings from other settings transfer unchanged. Comparative designs should investigate the same proposed mechanism while allowing its meaning to differ across groups. Research with multilingual students, disabled students, and students balancing paid work would also clarify how assistance interacts with existing barriers. Their experiences are necessary for evaluating who gains room to explore and who faces new constraints.

Research should also investigate how students recover from unsettling experiences. Discovering that a highly praised assignment contains generated errors can disrupt confidence and trust in assessment. A false accusation of misconduct can raise questions about belonging. A change in a conversational service can interrupt a relationship experienced as supportive. Following what students do afterward would clarify which institutional responses help them rebuild a credible account of their abilities and choices. Recovery is especially informative because it reveals the resources that support identity when routine expectations fail. It also directs attention to practices that universities can improve through advising, feedback, and fair review procedures.

IX. CONCLUSION

Artificial intelligence enters university students' self-identity through experiences of achievement, expression, recognition, and anticipation. Its developmental significance emerges when students interpret these experiences as evidence about their capacities and commitments. The same form of assistance can support exploration in one setting and encourage avoidance in another because attribution, assessment, and social relationships shape what students learn from it. This review connects those processes within an account of identity formation and identifies dependence, premature closure, unequal recognition, and constrained control over personal data as risks requiring specific investigation.

Universities can respond through tasks that make delegation discussable, assessments that reveal transferable understanding, and relationships that recognize students across time. These practices give students opportunities to judge assistance, acknowledge uncertainty, and revise commitments through experience. Institutional accountability also matters because students form identities within systems that

allocate attention and opportunity. The educational priority is to ensure that students can explain their decisions, understand the contributions behind their achievements, and participate in shaping the conditions under which they are evaluated. Those capacities support self-authorship as AI becomes part of everyday academic and professional life.

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The Contemporary Significance of Lifelong Education and Pathways for Its Implementation

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Abstract

Lifelong education is both an educational philosophy and an institutional framework that extends across the human lifespan, encompasses multiple spheres of activity, and connects society as a whole. It has emerged through the development of human civilization and the evolution of education itself. Drawing on the historical development of lifelong education, this article examines its contemporary significance and identifies five interrelated pathways for implementation: renewing educational concepts, strengthening institutional arrangements, expanding learning platforms, leveraging digital technologies, and fostering societal collaboration. Lifelong education is essential to holistic human development, provides strategic support for building a learning society and an education-oriented nation, and offers a response to technological transformation and demographic change. Its implementation requires coordinated action across three dimensions: enabling learning at any time, making learning accessible in any place, and ensuring opportunities for everyone. By integrating education throughout the life course and embedding learning in everyday social life, lifelong learning can become a widely shared way of life.

Keywords: lifelong education; lifelong learning; learning society; educational powerhouse; implementation pathways

I. INTRODUCTION

In the contemporary era, the pace of knowledge renewal is accelerating and occupational structures are changing rapidly. Traditional models of one-off education and the assumption that learning completed at one stage of life will remain sufficient indefinitely can no longer meet these demands. Knowledge continues to expand, technological innovation proceeds at an increasing pace, and social transformation is becoming more far-reaching. Neither individuals nor industries can rely solely on knowledge acquired during formal schooling to sustain development throughout an entire lifetime. Against this background, the temporal, spatial, and social boundaries of education have progressively expanded. Lifelong education, understood as an educational philosophy and an institutional framework extending beyond schooling and across the life course, has therefore become an increasingly important response to contemporary conditions.

Research on lifelong education addresses pressing issues at both macro and micro levels. At the macro level, the development of a learning society and a learning nation in which all citizens can engage in learning throughout life has become an important policy priority. At the micro level, workers face the continuing need to update their knowledge and develop new skills, while families must respond to the challenges of educational continuity across generations. A clearer understanding of the contemporary significance of lifelong education, together with feasible pathways for its implementation, is therefore of both theoretical and practical value to holistic human development.

II. ORIGINS AND CONCEPTUAL FOUNDATIONS OF LIFELONG EDUCATION

2.1 The historical evolution of lifelong education

The formal establishment of lifelong education as a concept dates to the mid-twentieth century. In 1965, the French adult educator Paul Lengrand presented a paper on continuing education at a UNESCO international meeting on adult education. His work helped articulate the view that education should be understood as a continuous process extending from birth to the end of life (Lengrand, 1985). This position fundamentally challenged the conventional assumption that education belongs to a limited period of an individual's life. In 1972, the International Commission on the Development of Education, chaired by Edgar Faure, published Learning to Be: The World of Education Today and Tomorrow. The report advanced lifelong education and the idea of a learning society as principles of educational reform, emphasizing that education should not be the exclusive domain of schools but should involve all stages of life and spheres of society (International Commission on the Development of Education, 1996).

In 1996, UNESCO's International Commission on Education for the Twenty-first Century published Learning: The Treasure Within. The report identified four pillars of education—learning to know, learning to do, learning to live together, and learning to be—and positioned learning throughout life as a central principle for education in the twenty-first century (UNESCO, 1996). Taken together, these milestones reflect a historical shift from advocacy of an educational ideal to broader international recognition, and from a focus on individual learning practices to the development of institutional structures supporting lifelong learning.

Since the beginning of the twenty-first century, the concept of lifelong education has continued to gain prominence internationally. Many countries have incorporated it into educational development strategies and explored mechanisms such as credit banks, qualifications frameworks, and the recognition of prior learning to connect education more closely with work and everyday life. China has likewise pursued locally adapted approaches, moving from the aspiration to build a learning society toward the broader goal of becoming a learning nation, while strengthening lifelong education systems and advancing digital transformation in education (Editorial Office of Educational Research, 2026).

2.2 Defining the scope of lifelong education

A clear definition is a prerequisite for assessing the significance of lifelong education and identifying practical approaches to its development. Conceptually, lifelong education can be understood through four interconnected dimensions: time, space, participants, and content.

The temporal dimension emphasizes continuity across the entire lifespan. Education is not confined to a single developmental stage but encompasses the period from early childhood to the end of life. Early childhood education, schooling, vocational education, and education for older adults are thus understood not

as disconnected episodes but as parts of a continuous developmental process. The spatial dimension emphasizes the breadth of learning contexts. Learning extends beyond the classroom into families, communities, workplaces, and digital environments, bringing together school-based, family-based, and wider social learning.

The participant dimension highlights inclusion and universal access. All individuals should have opportunities to receive education and continue learning, irrespective of age, occupation, or geographical location. Finally, the content dimension emphasizes comprehensive development. Lifelong education involves not only acquiring knowledge and practical skills but also cultivating ethical understanding, physical and mental well-being, aesthetic appreciation, and the capacity to act effectively in everyday life.

Lifelong education is therefore not an isolated component of the education system but an overarching philosophy of learning and development. Nor should it be viewed solely as a passive set of institutional provisions: it can also become an active orientation toward everyday life. By extending education beyond occupational preparation and particular stages of life, lifelong education transforms it into a continuous, inclusive, and socially embedded practice. Its underlying purpose is to support sustained personal development and social progress. This conceptual foundation is essential to understanding its contemporary importance and the pathways through which it can be realized.

III. THE CONTEMPORARY SIGNIFICANCE OF LIFELONG EDUCATION

The contemporary significance of lifelong education can be examined across interconnected individual, national, social, and historical dimensions. Together, these perspectives provide a comprehensive account of its value.

3.1 An essential condition for holistic human development

Lifelong education is an essential condition for holistic human development. Human development does not occur once and for all; rather, it is an ongoing process in which knowledge, competence, character, and psychological maturity are progressively cultivated. Formal schooling provides an important foundation, but it cannot address every challenge that an individual may face across a lifetime. Continuing to learn allows people to improve their abilities, adjust to changing environments, and pursue personal growth over time. Lifelong education also reflects the distinctive developmental tasks associated with different stages of life. Childhood and adolescence are important periods for establishing foundations and developing initial understanding; adulthood involves professional development and social responsibility; and later life offers opportunities for continued intellectual engagement, enjoyment of learning, and intergenerational transmission of knowledge. Lifelong education responds to these differing needs by providing appropriate opportunities and support throughout the life course.

3.2 Strategic support for a strong education system and a learning nation

Lifelong education provides strategic support for China's ambition to develop a strong education system and become a learning nation. National policy has called for the establishment of a lifelong education system that is widely accessible and for the development of a learning society. These priorities indicate that lifelong education should not be regarded as a supplementary component of the education system. Instead, it constitutes an integral element of an educational powerhouse and a defining feature of a learning society. Building a strong education system requires more than improving schools at different levels. It also involves establishing inclusive and accessible opportunities for learning throughout life, enhancing the quality of diverse forms of education, and reducing barriers between degree-granting and non-degree education as well as between formal, non-formal, and informal learning. Such measures can enable educational resources to benefit a wider population.

3.3 A response to technological and industrial transformation

Lifelong education is increasingly important in responding to technological change and industrial restructuring. Developments in artificial intelligence, big data, cloud computing, and related technologies are transforming production, daily life, and governance. Technological change creates new occupations while making some existing jobs less viable; similarly, it generates demand for new skills while reducing the relevance of others. Some estimates suggest that the pace at which knowledge becomes outdated has accelerated substantially, although the extent of this change varies across disciplines. In such circumstances, the knowledge gained through a single period of schooling cannot be assumed to remain sufficient throughout one's working life. Continuing education and learning are important for maintaining adaptability in the face of change.

Industrial transformation places additional demands on workers' knowledge and abilities. Modernization in established industries requires the adoption of new technologies, while expanding industries create demand for workers with emerging competencies. Workplace learning, professional training, and continuing education are therefore important components of workforce development. By helping workers update their competencies and adapt to changes in technology and employment, lifelong education can strengthen the relationship between individual career development and broader industrial transformation.

3.4 A practical response to demographic change

Lifelong education is also a practical response to demographic change. China is experiencing declining birth rates, population ageing, and widening regional differences in population growth and decline. These developments create new demands for educational provision. As the proportion of older adults increases, so does the need for learning opportunities in later life. Older adults require not only financial security and healthcare but also opportunities for education, participation, and meaningful activity. Expanding

educational provision for older adults can help them update their knowledge, enrich their cultural and intellectual lives, and enhance their quality of life, thereby contributing to active ageing.

At the same time, changes in the size and age composition of the working-age population increase the importance of improving existing human capital through continuing education. As demographic advantages associated with a large labour force diminish, the development of knowledge and skills becomes particularly important. By offering opportunities across the lifespan, lifelong education can support people of different ages and help offset some of the challenges associated with demographic restructuring through improvements in workforce capabilities and opportunities for participation.

3.5 A means of advancing educational equity and social well-being

Lifelong education can contribute to educational equity and social well-being. Equity in education concerns not only equal access to schooling but also the protection of opportunities to learn throughout life. Under conventional education arrangements, differences in geographical location, urban or rural residence, occupation, and age can produce substantial disparities in access. Some groups consequently have difficulty obtaining learning opportunities that meet their needs. Lifelong education can help address these gaps by extending educational services into communities, rural areas, and digital environments, and by strengthening open education, continuing education, community education, and learning for older adults. Such initiatives can expand access for people living in remote areas, disadvantaged groups, and older learners.

From the perspective of shared prosperity, lifelong learning can also help workers improve their knowledge, skills, and employability as their careers develop. By strengthening individuals' capacity to participate in economic and social life, it may help reduce inequalities in developmental opportunities. Lifelong education can further contribute to social well-being by fostering cultural literacy, civic responsibility, reflective judgment, and constructive attitudes toward social participation. These broader benefits support the development of a society in which opportunities for learning and development are more widely shared.

IV. PATHWAYS FOR IMPLEMENTING LIFELONG EDUCATION

Advancing lifelong education requires coordinated efforts in five areas: renewing educational concepts, strengthening institutional arrangements, expanding learning platforms, leveraging digital technologies, and promoting collaboration across society. Together, these areas can support a system in which everyone has opportunities to learn, learning is accessible across settings, and education is available throughout the life course.

4.1 Renewing educational concepts: Establishing lifelong learning as a shared value

Changes in practice begin with changes in understanding. The first priority in promoting lifelong education is to move beyond the assumption that education is a task completed during a particular stage of life. Learning should instead be recognized as an ongoing endeavour, while responsibility for education should be understood as extending beyond schools to society as a whole. Public communication, supportive policies, and practical examples can help establish a broader consensus that lifelong learning is both valuable and achievable. Opportunities for continuous learning can also be recognized in systems of personal and professional development, so that sustained effort is respected and achievements are acknowledged.

Educational institutions and professionals must likewise reconsider their roles. Rather than treating schools as the sole location of education, they can open educational resources to wider groups and strengthen connections between school-based provision and learning opportunities at other stages of life. In this way, teachers and institutions become not only providers of instruction but also supporters and facilitators of lifelong learning.

4.2 Strengthening institutions: Building an integrated lifelong learning system

Institutional arrangements provide the foundation for sustained implementation. A comprehensive lifelong learning system requires mechanisms that recognize and connect learning achieved through different routes and at different stages of life. First, a national qualifications framework can establish common principles for classifying, assessing, and recognizing educational achievements at different levels. Such a framework can link formal education, vocational training, and learning outside degree programmes, enabling both horizontal mobility across educational pathways and vertical progression to more advanced levels.

Second, credit banks can allow learners to record, accumulate, transfer, and, where permitted, redeem learning credits acquired in different institutions and contexts. This mechanism can reduce barriers between institutions and between educational and vocational pathways, while ensuring that learning achievements are recorded and recognized over time. Third, systems for the recognition of prior learning can assess skills and experience obtained outside formal education. By translating relevant occupational and everyday experience into recognized learning outcomes, these arrangements can give non-formal and informal learning a clearer institutional status.

4.3 Expanding learning platforms: Creating widely accessible opportunities

Learning platforms and spaces are essential to the provision of lifelong education. Broadening access requires infrastructure that reaches both urban and rural communities. One priority is to strengthen the open university system. Open universities play an important role in providing educational opportunities across

the lifespan, including degree-oriented continuing education and non-degree learning. Improving their coordination and capacity can create more inclusive learning opportunities for different members of society.

A second priority is community education. Developing local learning networks can bring educational resources closer to residents and make communities important sites of lifelong learning. A third priority is education for older adults. Strengthening universities and learning centres for older people, extending services to local communities, and diversifying programme content can create opportunities for continued engagement and enjoyment in later life. Finally, cities can systematically incorporate lifelong learning into urban planning, public services, and community governance. The development of learning cities can help foster a local culture in which continuing education is valued and supported.

4.4 Digital empowerment: Opening new spaces for lifelong learning

Digital technologies can greatly expand the reach of lifelong education. First, accessible digital learning platforms can bring together high-quality educational resources and make them available to learners regardless of their physical location. In China, the National Smart Education Public Service Platform offers a potential foundation for broadening access to digital content and supporting the sharing of educational resources.

Second, diverse digital learning resources should be designed for people of different ages, occupations, prior knowledge, and learning needs. Courses and resources with varied content and formats can better accommodate heterogeneous learners. Third, digital approaches to learning can be expanded through technologies such as artificial intelligence and virtual reality. These technologies offer possibilities for immersive, interactive, and personalized learning environments and for providing support adapted to individual needs. Fourth, digital literacy should be developed across the population. Supporting learners, including older adults, in acquiring the capabilities needed to use digital tools can help reduce the digital divide and ensure that technological advances contribute to more equitable opportunities for learning.

4.5 Societal collaboration: Establishing shared responsibility for lifelong education

Lifelong education is a systemic undertaking that requires cooperation among governments, educational institutions, social organizations, families, and individuals. Government coordination is a first priority. Authorities at different levels can incorporate lifelong education into economic, social, and educational development planning, strengthen policy and financial support, and coordinate the allocation of learning resources. Educational institutions should also play a leading role by opening their resources, providing training, and drawing on their expertise to serve learners beyond their existing student populations.

Broader participation is equally important. Employers, public institutions, social organizations, and community bodies can contribute to lifelong education by providing varied learning and training opportunities. In particular, workplace systems that support employee learning can encourage continuing

professional development. Families can cultivate environments that value learning, while individuals can take an active role in developing and maintaining a lifelong learning orientation. Cooperation across these levels can help make learning a routine and accessible part of everyday life.

V. CONCLUSION

Lifelong education reflects both the broader development of human civilization and changes within education itself. Its contemporary significance lies in supporting holistic human development, advancing national educational goals, responding to technological and demographic change, and meeting the public's evolving educational needs. Realizing these aims requires mutually reinforcing efforts to renew educational concepts, establish integrated institutions, broaden learning opportunities, use digital technologies effectively, and engage actors across society. Looking ahead, education should be sustained throughout the life course and learning should be more fully integrated into everyday life. Making lifelong learning a widely accessible and valued practice can create opportunities for individuals to develop their capabilities and pursue more fulfilling lives.

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When Answers Come Before Questions: Does Generative Artificial Intelligence Weaken Students' Independent Thinking?

An Educational Argument for Protecting Cognitive Agency

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Abstract

The rapid adoption of generative artificial intelligence (GenAI) in education has renewed a fundamental question: does convenient access to machine-generated explanations, arguments, and solutions weaken students' willingness and capacity to think independently? The question cannot be answered by treating AI use as a single behavior or equating fluent academic products with genuine learning. This conceptual and argumentative article examines the conditions under which GenAI may displace, rather than support, essential cognitive activity. Drawing on cognitive offloading, self-regulated learning, cognitive load theory, the ICAP framework, and emerging experimental and review evidence, it distinguishes immediate task performance from durable competence and behavioral compliance from intellectual agency. Three risks are emphasized: premature delegation of problem formulation and reasoning, uncritical acceptance of plausible outputs, and reduced practice in monitoring and correcting one's own understanding. Equally, structured AI tutoring, dialogic challenge, formative feedback, and accessibility support can extend opportunities for deeper learning. The article proposes a pedagogical principle of protected cognitive agency: students should retain responsibility for defining questions, constructing initial explanations, evaluating evidence, and demonstrating independent transfer, even when AI assists with peripheral operations. A four-phase instructional sequence—attempt, consult, contest, and reconstruct—is offered as a practical heuristic rather than an empirically validated intervention. Implications for assessment, teacher practice, equity, and longitudinal research are discussed. The central conclusion is conditional: GenAI does not inevitably diminish independent thinking, but educational systems can create that outcome when they reward polished answers without protecting the mental work through which understanding is formed.

Keywords: generative artificial intelligence; independent thinking; cognitive agency; critical thinking; cognitive offloading; self-regulated learning; higher education; educational assessment

Article type: Conceptual and argumentative article

I. INTRODUCTION: THE EDUCATIONAL PROBLEM BEHIND THE CONVENIENT ANSWER

For a student confronted with an unfamiliar concept, a blank page, or a complex mathematical problem, generative artificial intelligence offers an apparently ideal response: an explanation arrives immediately, a structure appears without hesitation, and a persuasive answer can be produced in seconds. This convenience is not merely another improvement in access to information. A search engine normally offers material that students must interpret and connect; an AI chatbot can present the interpretation, connection, and final expression together. It can therefore participate in the very intellectual operations that schooling is intended to cultivate.

The resulting controversy is often framed as a choice between technological progress and intellectual decline. Optimistic accounts emphasize personalized tutoring, faster feedback, expanded access, and the democratization of academic assistance. Pessimistic accounts warn that students will cease to question, tolerate uncertainty, or persist through demanding intellectual tasks. Both positions identify genuine possibilities, but neither adequately explains why the same technology can support serious inquiry in one classroom and superficial completion in another. The more consequential issue is the organization of cognitive labor: what does the student still have to think through, and what has the system already thought through on the student's behalf?

This distinction matters because education has two different outputs that frequently look alike. One is a completed task: an essay, worked solution, presentation, or research summary. The other is a learner who has acquired knowledge, judgment, and habits that can be applied to a new task without external assistance. GenAI can improve the former without necessarily improving the latter. Indeed, the gap between visible product quality and invisible cognitive development may be one of the defining educational challenges of the current period. A professionally written response is not proof that its apparent author can explain, defend, or reconstruct the reasoning behind it.

There is already empirical reason to resist simplistic conclusions. In a field experiment with high-school mathematics students, Bastani et al. (2025) found that access to a relatively unrestricted AI assistant improved performance during practice but was associated with poorer subsequent performance when assistance was removed; the negative learning effect was largely mitigated by a more carefully constrained tutoring system. Conversely, Kestin et al. (2025) reported learning advantages from an AI tutor intentionally designed around established instructional principles. These studies differ in setting, design, and comparison, so neither should be treated as a universal verdict. Together, however, they suggest that the educational consequences of AI depend not simply on access but on the kind of interaction that access makes likely.

This article argues that the relevant danger is not the disappearance of thought but the weakening of **cognitive agency**: students' capacity and disposition to initiate inquiry, choose a strategy, evaluate reasons, monitor misunderstanding, and take responsibility for conclusions. The argument is developed in five steps. First, independent thinking is defined more precisely than the popular phrase “thinking for oneself.” Second, the cognitive mechanisms through which assistance can become substitution are examined. Third, current evidence is assessed without confusing short-term productivity with long-term learning. Fourth, a conditional framework is presented for distinguishing productive from unproductive AI use. Finally, implications are drawn for classroom design, assessment, educational equity, and future research. The objective is neither to prohibit AI nor to celebrate its novelty, but to identify which intellectual activities education must preserve in an AI-rich environment.

II. WHAT DOES IT MEAN FOR STUDENTS TO THINK INDEPENDENTLY?

Independent thinking should not be confused with solitary thinking. Students develop reasoning through teachers, books, peers, cultural tools, and disciplinary communities. A student who consults a textbook or debates an idea with a classmate is not thereby less independent. Independence refers instead to the learner's control over the purposes, justification, and revision of an intellectual judgment. It is possible to think independently while using assistance, just as it is possible to behave passively while working alone.

At least four dimensions deserve separate consideration. **Initiative** is the readiness to recognize a problem, formulate a question, or pursue a discrepancy rather than merely wait for instructions. **Generative reasoning** is the ability to produce tentative explanations, interpretations, hypotheses, or solution paths from one's current knowledge. **Epistemic evaluation** involves judging the reliability of claims, the relevance of evidence, and the strength of alternative explanations. **Metacognitive regulation** concerns planning, monitoring comprehension, identifying errors, and adjusting strategies. None is equivalent to producing a polished final document, and each can be obscured when an AI system delivers that document.

The ICAP framework provides a useful lens. Chi and Wylie (2014) distinguish passive, active, constructive, and interactive forms of engagement, with stronger learning expected when learners generate new inferences and build ideas through meaningful interaction rather than merely receive information. AI use can occupy any of these modes. Copying an explanation is predominantly receptive. Highlighting or editing it may involve activity without substantial conceptual construction. Asking the system to critique a student-generated hypothesis may invite constructive engagement, while sustained dialogue in which the student develops, tests, and revises an argument may approximate an interactive learning process. The presence of a chatbot is thus not itself evidence of active learning; the cognitive operations performed by the learner must be examined.

This conceptual precision also prevents unfair comparisons. Before concluding that AI has reduced independent thinking, researchers must specify the baseline: compared with independent study, ordinary internet searching, teacher tutoring, peer collaboration, or a less structured AI interface? A student using AI to translate unfamiliar terminology might become more independent in a demanding science discussion than a student excluded from such support. By contrast, one who delegates the central inference in a logic exercise may lose precisely the opportunity the exercise was designed to provide. The same act of assistance can have a different educational meaning according to the target competence.

III. HOW ASSISTANCE BECOMES SUBSTITUTION: COGNITIVE AND MOTIVATIONAL MECHANISMS

3.1 Cognitive offloading and the location of intellectual work

Cognitive offloading refers to the use of external resources or actions to reduce demands on internal processing (Risko & Gilbert, 2016). Writing down a calculation, using a calendar, or consulting a reference work can be highly adaptive. Human cognition has never operated without tools, and efficient external support can release attention for demanding decisions. The educational problem begins when the delegated activity is not a dispensable burden but the very operation students need to learn.

Consider two uses of AI during an argument-writing assignment. A student who has already developed a position may ask for help identifying ambiguous transitions or improving the readability of a paragraph. Such assistance can remove peripheral obstacles while leaving argumentative decisions with the learner. Another student may prompt the system to select the thesis, provide evidence, anticipate objections, and compose the conclusion. In the second case, the essential cognitive labor has been transferred. The result may be rhetorically impressive, but the student's opportunity to practise constructing an argument has narrowed.

This distinction is compatible with Nakamura's (2026) augmentation–erosion framework, which emphasizes whether externalized operations are peripheral or constitutive of the learning goal. It also cautions against assuming that any reduction in cognitive effort is undesirable. Offloading routine formatting, spelling, or navigation may be sensible when the objective is to understand a scientific mechanism. But offloading hypothesis generation during a lesson intended to teach hypothesis generation has a fundamentally different effect. The danger is not efficiency itself; it is a mismatch between efficient task completion and the cognitive purpose of the task.

3.2 Cognitive load: less effort is not always more learning

Cognitive load theory helps clarify the apparent paradox. Learners have limited working-memory capacity, and unnecessary demands can interfere with the construction of useful knowledge structures (Sweller, 1988). An AI tutor that clarifies confusing instructions, sequences a difficult explanation, or supplies a timely hint may reduce unproductive burden and permit deeper processing. An interface that removes every meaningful challenge can, however, eliminate occasions for explanation, retrieval, discrimination, and revision.

Research on retrieval practice is relevant here. Roediger and Karpicke (2006) showed that retrieving information can improve later retention even when re-exposure feels easier. More broadly, Dunlosky et al. (2013) identify practice testing and distributed practice as effective learning techniques. AI-generated summaries can create a reassuring sense of familiarity, but recognition of a well-written explanation is not

the same as being able to reconstruct it. Students may confuse ease of comprehension while reading an answer with mastery of the process required to produce an answer independently.

3.3 Metacognitive outsourcing and false confidence

Effective independent learners do more than select correct answers: they notice uncertainty, check progress, and diagnose errors. Zimmerman's (2002) account of self-regulated learning emphasizes forethought, performance regulation, and self-reflection. If a chatbot continuously supplies plans, identifies mistakes, proposes revisions, and judges adequacy, students may have fewer reasons to exercise these regulatory functions. They can become skilled at obtaining corrections without becoming skilled at detecting the need for correction.

A related risk is miscalibrated confidence. The fluency and apparent coherence of AI-generated explanations may make understanding seem more complete than it is. Students who can follow a response may assume they could have generated it. Yet this assumption can be tested only through unaided explanation, application, or transfer. The solution is not perpetual distrust of AI, which would be exhausting and impractical, but informed judgment concerning which claims require checking and which reasoning steps a learner must be able to perform independently.

3.4 Motivation, autonomy, and intellectual persistence

Independent thinking is partly motivational. Students must decide that a question is worth pursuing and that their own effort can make a difference. Self-determination theory identifies autonomy and competence as central conditions for high-quality motivation (Ryan & Deci, 2020). GenAI can support both by offering responsive explanations and reducing the embarrassment of asking a question. It can also undermine both when learning is experienced as selecting among machine-produced answers rather than exercising authorship over an inquiry.

The mechanism is subtle. Immediate relief from uncertainty is rewarding, especially under deadlines. Repeated reliance may gradually alter students' expectations about how much personal effort is normal before seeking an external solution. This is a plausible developmental pathway, not proof that AI causes generalized laziness. It suggests, however, that the design of tasks and feedback may influence whether students interpret effort as a valuable route to competence or as an obstacle that ought always to be bypassed.

IV. WHAT DOES THE EMERGING EVIDENCE ACTUALLY ESTABLISH?

A responsible educational argument must distinguish experimental findings, research syntheses, and theoretical possibilities. The literature is expanding quickly, but studies use different tools, ages, subjects,

measures, and instructional arrangements. A claim that GenAI either improves or harms "thinking" across education would exceed what these heterogeneous outcomes can establish.

Bastani et al. (2025) provide unusually direct evidence for the distinction between supported performance and independent learning. In a field experiment involving nearly one thousand high-school mathematics students, an unrestricted GPT-based assistant produced substantial gains while it was available. Yet students in that condition scored lower on a subsequent assessment after AI access was removed than peers who had never received the tool. A more constrained AI tutor, designed to provide pedagogically useful guidance instead of simply disclosing answers, largely avoided that penalty. The lesson is specific but powerful: the same family of tools can generate very different learning outcomes depending on whether it invites answer acquisition or problem-solving.

Stadler et al. (2024) reached a related conclusion in a randomized study of 91 university students investigating a socio-scientific issue. Compared with students using conventional web search, those using a language model reported lower cognitive load but produced weaker reasoning and argumentation in their final recommendations. This finding does not demonstrate permanent cognitive decline. It does, however, challenge the assumption that faster access to synthesized information necessarily creates deeper understanding. The instructional value of cognitive ease must be judged against the quality of the reasoning that follows it.

Writing research offers another warning against substituting product quality for learning. In a randomized experiment with 117 university students comparing several forms of support, Fan et al. (2025) observed better essay-score improvement in the ChatGPT condition without corresponding significant advantages in knowledge gain or transfer. The authors also identified process patterns compatible with overdependence and weakened metacognitive engagement. These results should not be extended automatically to every writing context, but they support the view that improved artifacts and stronger learner competence are empirically separable outcomes.

Evidence on the benefits of AI is equally important. Kestin et al. (2025) evaluated a deliberately designed AI tutor in college-level physics instruction and reported greater learning in less time than in a comparison active-learning class, together with favorable student perceptions. The intervention incorporated established instructional practices rather than allowing unrestricted answer generation. Its findings counter the notion that assistance necessarily suppresses learning. AI can deliver effective scaffolding, especially when the learning process—not merely the final output—is what the system is configured to support.

The wider evidence base is mixed rather than uniformly negative. Chen and Cheung's (2025) meta-analysis synthesized 57 studies of university learning and reported positive average effects on several outcomes, including academic achievement and higher-order thinking, but no statistically significant average effect on metacognition. Such pooled results are informative about broad tendencies, yet their

educational interpretation depends on study quality, outcome definitions, duration, and whether assessments required independent performance. A positive average effect on measured reasoning tasks does not prove a long-term increase in intellectual autonomy; equally, a null metacognitive estimate does not prove deterioration.

More recent longitudinal and synthesis work reinforces the importance of context. Melanou et al. (2026), examining three instructional conditions across a semester with 87 students, found gains in knowledge across conditions but no additional overall benefit from AI integration; reflective use was associated with critical thinking. A scoping review by Lin et al. (2026) mapped 394 empirical higher-education studies and noted that much of the field still relies on short-term, readily measured outcomes, while self-regulated learning and equity receive comparatively less attention. Since a scoping review maps research rather than establishing causal efficacy, it should not be interpreted as a verdict on whether AI enhances or erodes thinking.

Evidence from outside classrooms can clarify mechanisms without proving student outcomes. Lee et al. (2025) surveyed 319 knowledge workers and found that greater confidence in GenAI was associated with less self-reported critical-thinking effort, whereas greater confidence in one's own abilities was associated with more. Respondents described a shift from information generation toward verification and integration. Because the evidence is self-reported and drawn from work settings, it cannot establish that students' critical-thinking abilities decline. It nevertheless highlights a potentially important transition: cognition may change its location and character rather than simply increase or disappear.

Taken together, these findings justify a conditional proposition. Unstructured AI assistance can reduce the amount of independently performed reasoning in an educational task, and in some settings this can impair later unaided performance. Well-designed AI assistance can support learning, sometimes substantially. Whether repeated patterns produce enduring changes in initiative, intellectual confidence, or domain-general critical-thinking ability remains insufficiently established. Claims about permanent decline should therefore be treated as research hypotheses rather than settled facts.

V. THREE PATHWAYS THROUGH WHICH INDEPENDENT THINKING MAY WEAKEN

5.1 Premature closure: receiving a question's answer before constructing the question

The first pathway is premature closure of inquiry. Many educational tasks are valuable precisely because students must determine what is being asked, decide what information matters, and consider competing approaches. An AI response can collapse these stages into a ready-made interpretation before the student has experienced the uncertainty that motivates inquiry. A learner assigned to discuss whether a policy is just, for example, may ask a chatbot for a balanced essay and receive familiar arguments on both

sides. What is lost is not only writing practice; it is the prior work of deciding which competing definitions of justice are relevant and what evidence would distinguish them.

This risk is especially important in disciplines where framing is a major component of expertise. Historical interpretation requires selecting and contextualizing sources; scientific research requires generating testable questions; literary criticism requires attending to ambiguity; education research requires distinguishing normative claims from causal explanations. An AI answer can be useful after students have made an initial interpretive commitment. Delivered too early, it may narrow the space of possibilities they would otherwise have explored.

5.2 Epistemic passivity: mistaking plausibility for justification

The second pathway is epistemic passivity. Generative systems are optimized to produce plausible responses, not to guarantee the truth of every statement or the adequacy of every inference. In academic work, however, a claim becomes acceptable through evidence, valid reasoning, and accountability to disciplinary standards. Students who treat AI output as a convenient authority may skip the intermediate question: why should this conclusion be believed?

A sophisticated form of passivity can hide behind extensive editing. Students may reorganize paragraphs, change examples, or improve style while retaining an unsupported premise supplied by AI. Observable activity is therefore not sufficient proof of critical engagement. Evaluative reasoning requires confronting substantive alternatives, searching for disconfirming evidence, and identifying conditions under which a conclusion would change. It is particularly demanding when AI output matches the learner's prior beliefs or appears in authoritative academic language.

This risk also changes what teachers must teach. Traditional information literacy frequently emphasizes evaluating sources and distinguishing scholarly from non-scholarly material. GenAI requires an additional level of scrutiny because individual sentences can be fluent yet untraceable to a verifiable source. Independent thinkers must ask whether a reference exists, whether quoted claims accurately represent it, whether opposing evidence has been excluded, and whether a persuasive synthesis conceals conceptual inconsistency.

5.3 The erosion of self-monitoring through repeated rescue

The third pathway is the repeated external correction of difficulties that students could learn to manage. When an AI tutor immediately detects every error and supplies the next action, students may become less practised at recognizing when a strategy has failed. Over time, the learner's internal question—"What am I misunderstanding?"—can be replaced by the operational question—"What should I ask the chatbot next?" The latter can be efficient, but it is not a substitute for the former.

Evidence from a year-long behavioral-sequence study by Dai et al. (2026) is suggestive: higher-performing graduate-student groups maintained more critical patterns of AI engagement, whereas lower-performing groups showed patterns consistent with greater cognitive outsourcing. Because these patterns were observed at the group level and do not establish causation, they cannot prove deterioration produced by AI. They do, however, indicate why averages can conceal divergent developmental trajectories. Some students learn to interrogate the technology; others may increasingly delegate the work of interrogation.

These pathways can reinforce one another. Premature answers reduce opportunities for initial hypothesis formation; persuasive outputs lower the perceived need for evaluation; continuous correction reduces practice in monitoring. Together, they may gradually alter classroom norms about what counts as learning. The critical issue is not the number of prompts students send, but whether interaction with AI strengthens their ability to act without it.

VI. WHY GENAI CAN ALSO STRENGTHEN ACTIVE AND INDEPENDENT THINKING

A credible argument must address the opposite possibility: AI can enlarge intellectual agency when it makes previously inaccessible forms of inquiry possible. Students often experience barriers that are not themselves the intended learning target. Limited vocabulary, unfamiliar terminology, language anxiety, inaccessible materials, or delayed teacher feedback can prevent them from engaging in demanding conceptual work. Responsive explanations and adaptive hints can reduce these barriers. When assistance helps learners enter a task rather than complete it for them, cognitive offloading is potentially enabling.

A second opportunity is dialogic challenge. A conventional textbook cannot readily question a student's reasoning or generate counterexamples tailored to an initial claim. A carefully constrained AI interlocutor can ask, “What evidence would disprove this interpretation?” or “How does this conclusion change if the underlying assumption is false?” Such exchanges can sustain constructive engagement when the student must answer in their own terms. In this use, the technology serves as a source of productive resistance rather than a supplier of finished judgments.

Third, AI can support formative assessment. Teachers face limited time, especially in large classes, and students may receive feedback only after the opportunity for revision has passed. AI-supported feedback can identify places where explanations are incomplete or provide practice questions targeted to misunderstandings. For these benefits to count as learning rather than mere correction, students must interpret the feedback, explain what they changed, and later demonstrate that they can apply the principle independently.

Finally, responsible AI use can itself become an object of critical education. Students can learn how probabilistic language systems generate text, why answers vary with prompts, what data biases can shape outputs, and why apparent confidence is not evidence. UNESCO's AI competency framework emphasizes a

human-centered mindset alongside ethical and technical understanding (Miao et al., 2024). These capabilities are increasingly relevant to informed participation in social and professional life. An educational response focused only on prohibition would leave students less prepared to make responsible decisions in environments where AI is widespread.

The educational objective is therefore not maximal student effort or minimal AI use. It is a defensible division of labor: AI should reduce barriers to learning while preserving, and sometimes intensifying, the forms of reasoning students need to master.

VII. PROTECTED COGNITIVE AGENCY: A CONDITIONAL PRINCIPLE FOR AI INTEGRATION

The argument so far supports a guiding principle: **protected cognitive agency**. This term is used here to describe an instructional commitment, not a newly validated psychological scale or a theory claiming unique explanatory priority. The principle holds that learners should retain meaningful control over four responsibilities: defining the intellectual problem, developing an initial account, evaluating competing reasons, and demonstrating that understanding can be reconstructed without the system. Assistance may be extensive, but these responsibilities should not be routinely surrendered when they constitute the educational target.

The principle has three dimensions. The first is **temporal**: when is the system introduced? Assistance before any initial attempt can preempt the student's generation of hypotheses; assistance after a genuine attempt can serve as informative feedback. The second is **functional**: which operation is assigned to the system? Automating citation formatting differs from automating source evaluation; translating instructions differs from choosing a research question. The third is **accountability-based**: can the student explain, test, and transfer the resulting knowledge without simply repeating the system's wording? A fourth, **developmental**, dimension concerns how these choices change as a learner gains expertise. Novices may require more explanation and structured support, whereas advanced students should progressively assume responsibility for evaluating, adapting, and challenging it.

From these dimensions, a practical sequence can be derived: **attempt, consult, contest, reconstruct**. In the attempt phase, students first generate a question, provisional claim, worked step, or explanation without AI assistance. This initial work establishes an independent intellectual position and reveals uncertainty. In the consult phase, students use AI for targeted feedback, hints, comparison, or alternative perspectives rather than simply requesting a completed answer. In the contest phase, they actively test the output against evidence, identify errors or assumptions, and explain why they accept or reject suggestions. In the reconstruct phase, they produce an account or solve a related problem without access to the earlier AI response.

The sequence is a pedagogical heuristic, not a claim that every subject or learner should follow an identical rigid procedure. In an accessibility context, initial AI support may be necessary before a student can make any meaningful attempt. In advanced research, consultation and contestation may recur repeatedly rather than proceed linearly. Nevertheless, the four phases specify what a teacher can observe and what an assessment can require. They shift attention from whether AI was used to how the student exercised judgment around its use.

VIII. IMPLICATIONS FOR TEACHING: DESIGNING TASKS THAT REQUIRE THOUGHT

The first implication is to design learning activities around intellectual decisions rather than only deliverable products. Asking students to submit an essay on a familiar topic is increasingly insufficient evidence of independent reasoning. Asking them to formulate competing theses, justify the selection of evidence, identify weaknesses in a model explanation, or explain how a counterexample changes their position makes the process more visible. Teachers need not prohibit AI to achieve this; they can specify which decisions must be made by students and which supports are permissible.

Second, AI interaction should be scaffolded according to the learning objective. When the goal is mathematical reasoning, a tutoring interface can reveal a hint or ask a diagnostic question before providing a complete solution. When the goal is source criticism, the system may be asked to produce competing claims that students must substantiate using original documents. When the goal is writing style, grammar assistance may be appropriate, but students should still establish the claim and justify its evidential basis. The key design test is whether the learner must perform the cognitive operation that the lesson claims to develop.

Third, teachers should normalize constructive uncertainty. Students may turn to AI prematurely because they interpret hesitation as evidence that they are incapable of succeeding. Short periods of unaided brainstorming, prediction, or explanation can make uncertainty a routine part of learning. These phases need not be punitive or excessively long. A three-minute independent attempt followed by a structured comparison with AI feedback may be more educationally useful than either unlimited struggle or immediate disclosure of the answer.

Fourth, classrooms should explicitly teach verification. A useful task is to give students an AI-generated explanation containing a mixture of accurate statements, incomplete reasoning, and a plausible but unsupported claim. Students must identify what can be accepted, what requires evidence, and what must be corrected. However, such exercises should not reduce verification to a game of spotting intentionally planted mistakes. In authentic inquiry, the more demanding question is often how to evaluate an answer that is mostly correct but conceptually incomplete. Students need criteria drawn from the relevant discipline, not only generic skepticism.

Fifth, teachers should require reflection that goes beyond reporting which tool was used. Process notes can ask students to identify their initial position, describe a significant disagreement with AI, explain the evidence that resolved it, and specify what they would do differently in the next task. A disclosure statement establishes transparency; a reasoned reflection can reveal learning. The two functions should not be confused, and neither should become a bureaucratic substitute for actual reasoning.

Sixth, peer discussion remains valuable. AI conversations are personalized, responsive, and private, but education also depends on encountering real disagreement and negotiating meaning with other people. Small-group defense of alternative solutions can reveal assumptions that individuals overlook. Students may bring AI-generated counterarguments into discussion, but responsibility for evaluating them should remain social and human. UNESCO's guidance for GenAI in education emphasizes protecting human agency and maintaining opportunities for independent reasoning and interpersonal learning (Miao & Holmes, 2023).

Seventh, educators need realistic implementation rules. A blanket demand to verify every sentence would impose an unsustainable burden, and absolute bans may be unenforceable or inequitable. A more workable policy distinguishes low-stakes assistance, substantive intellectual contribution, and high-stakes evaluation. Students could use AI for accessible explanations or language support while disclosing substantial contributions to argumentation or analysis. Teachers, in turn, should make clear why certain stages require independent work, connecting restrictions to learning goals rather than treating every AI interaction as misconduct.

IX. RETHINKING ASSESSMENT: FROM POLISHED PRODUCTS TO DEMONSTRABLE UNDERSTANDING

Traditional assessment can become misleading when the quality of an artifact no longer reliably indicates the competence of the person submitting it. This does not make essays, projects, or take-home assignments obsolete. It requires greater clarity about what they measure. A well-written essay may demonstrate a successful human–AI production process, but it cannot by itself establish the student's unaided analytical proficiency. If institutions continue to infer the latter from the former, they may reward students for work they have not learned to perform.

A defensible assessment system can combine supported and unsupported performance. Students may develop a project with AI, while also completing a short independent explanation, a transfer problem, or an oral defense. The objective is not to catch students using technology; it is to establish whether the learning goals have been achieved. For some disciplines, independent recall and procedural fluency are essential. For others, the central competence is evaluating evidence, making ethical judgments, or applying concepts

under uncertainty. The assessment method should follow the construct rather than a uniform rule about technology.

Process-sensitive evaluation can also help. Version histories, brief reasoning journals, annotated decision points, and selective interviews may reveal whether students developed an argument or merely accepted one. Yet extensive process surveillance raises privacy concerns and can transform education into performative compliance. The purpose should be to sample meaningful cognitive decisions, not to collect exhaustive records of every keystroke or prompt. Students should understand what evidence is being requested and why.

A useful assessment distinction is between **performance with AI**, **immediate performance without AI**, and **delayed transfer without AI**. The first describes assisted productivity; the second indicates current accessible competence; the third provides stronger evidence of retained and transferable learning. All three are educationally relevant, but they answer different questions. A course claiming to develop independent reasoning should not rely exclusively on the first measure. The experimental contrast used by Bastani et al. (2025) illustrates why the removal of assistance can reveal outcomes that remain invisible during supported practice.

Fairness also matters. Students differ in access to paid tools, stable internet connections, prior AI literacy, language proficiency, and support from teachers. Assessment should not assume identical technological opportunities or punish students whose accommodations legitimately involve assistive software. Institutions should articulate assessment conditions in advance and provide accessible alternatives. The objective is a valid interpretation of learning, not an idealized image of unsupported work that disregards ordinary educational resources.

X. EQUITY, INSTITUTIONAL INCENTIVES, AND THE HIDDEN CURRICULUM OF EFFICIENCY

AI integration does not occur in a neutral environment. Students face grade competition, scholarship requirements, overloaded schedules, and assignments that may reward conformity more visibly than curiosity. If institutions assess only finished products, students have rational incentives to use tools that improve those products quickly. It is therefore too simple to blame a perceived decline in independent thinking on individual students' lack of discipline. Educational structures can make cognitive outsourcing the efficient response to the incentives they create.

The benefits and risks are also distributed unevenly. Students with stronger prior knowledge are often better positioned to notice weak reasoning, formulate informative prompts, and use AI as a critic. Those with limited foundational understanding may find plausible but flawed answers more difficult to challenge. This creates the possibility that the same technology could strengthen the agency of already-advantaged

learners while increasing dependence among others. The possibility deserves investigation rather than assumption: Melanou et al. (2026), for example, found no evidence of an increased performance divide in their relatively small semester-long study. Unequal outcomes should be treated as a conditional risk, not an inevitable result.

At the same time, restricting assistance can disadvantage learners who use AI to overcome language barriers, disability-related constraints, or limited access to human tutoring. An equitable policy must therefore separate the intellectual work that defines the learning objective from barriers that are irrelevant to that objective. If students are learning causal inference, grammar correction may improve fairness; if they are learning academic English composition, writing assistance may need clearer limits. The relevant distinction is pedagogical, not merely technological.

Institutions should also reconsider productivity-centered language. If students repeatedly hear that successful learning means producing more pages, answering faster, and eliminating uncertainty, they may internalize the idea that thinking is an avoidable cost. A more defensible educational culture values the quality of questions, the revision of beliefs, and the capacity to provide reasons. GenAI makes that cultural decision urgent because it can produce an appearance of mastery at unprecedented speed.

XI. A RESEARCH AGENDA FOR TESTING CLAIMS OF COGNITIVE DECLINE

The most important unresolved question is longitudinal. Does repeated use of GenAI change students' independently demonstrated reasoning capacities or their willingness to exercise them across months and years? A short experiment can show effects on a particular task, but enduring developmental claims require stronger evidence. Researchers should distinguish temporary performance dependence, loss of practice in a narrow skill, generalized transfer deficits, and changes in motivational habits. These are related but not interchangeable outcomes.

A first priority is to manipulate the **division of cognitive labor**, not merely AI access. Studies could randomly assign learners to unaided work, unrestricted answer generation, hint-based tutoring, and an attempt–consult–contest–reconstruct procedure. The interfaces should be matched as far as possible for time, content availability, and usability. Such designs would test whether preserving initial generation and subsequent reconstruction changes independent learning beyond the benefits of receiving feedback. Pre-registration and fidelity checks would help prevent selective interpretation of complex outcomes.

A second priority is multimethod measurement. Independent-thinking dispositions can be assessed through validated questionnaires, but surveys alone cannot demonstrate reasoning quality. Behavioral tasks should measure spontaneous question generation, argument evaluation, error detection, explanation revision, and strategic persistence. Process traces can show when students seek help and whether they examine responses critically. Interviews may clarify students' intentions. Crucially, measurement models should

distinguish cognitive initiative, reasoning ability, metacognitive monitoring, and intellectual confidence rather than treating them as interchangeable indicators of a single poorly defined outcome.

A third priority is to evaluate delayed and novel performance. Immediate post-tests may reflect familiarity with examples seen during AI-supported practice. Researchers should therefore include delayed tests and tasks requiring transfer to unfamiliar cases. When possible, they should assess both performance with and without AI. The difference between these conditions provides a direct indicator of reliance on assistance, although even that difference must be interpreted relative to task difficulty and the learner's prior knowledge.

A fourth priority is to examine developmental and disciplinary moderators. Younger learners, novices, students learning in a second language, and advanced researchers face different cognitive demands. In mathematics, worked steps may be central to learning; in historical research, source evaluation and contextual interpretation may be more important; in creative writing, developing an original voice may be the target. A single universal rule for acceptable offloading would ignore these differences. Experimental designs should explicitly specify which operations are peripheral and which constitute the learning goal.

Finally, research should include implementation failures and unequal effects. Carefully engineered AI tutors can perform differently from freely available systems that students use without instructions. Studies conducted with enthusiastic instructors may not generalize to crowded classrooms. Tool updates can also alter behavior during a trial, making transparent reporting essential. Rather than asking for a single average answer to whether AI weakens thinking, the field should specify which learners, tools, pedagogies, and assessment systems produce which developmental trajectories. That is a more demanding research agenda, but it is also more educationally useful.

XII. CONCLUSION: THE RIGHT TO THINK, AND THE RESPONSIBILITY TO TEACH THINKING

The concern that generative AI may weaken students' independent thinking is legitimate, but its strongest formulation is not that using AI inevitably makes students less intelligent or less capable. The more defensible concern is that some forms of AI use bypass repeated opportunities to formulate questions, construct explanations, evaluate evidence, and monitor error. When educational systems reward finished answers more than the reasoning needed to produce them, powerful generative tools can intensify an existing weakness in pedagogy.

The empirical record does not support a general claim of irreversible cognitive decline. It shows that unrestricted assistance can undermine later independent performance in some settings, while well-designed tutoring can improve learning in others. Theoretical accounts of cognitive offloading, self-regulation, and constructive engagement explain why these apparently contradictory outcomes can coexist. Their common

lesson is that cognition is not protected merely by reducing screen time or maximizing visible effort. It is protected when the learner continues to perform the intellectual operations necessary for growth.

The proposed principle of protected cognitive agency gives this lesson a practical form. Students should be supported in attempting problems, consulting resources, contesting claims, and reconstructing understanding. Teachers should evaluate independent competence alongside AI-assisted productivity, and institutions should align incentives with genuine learning rather than polished output alone. The decisive educational question is therefore not whether students are permitted to use artificial intelligence, but whether they are being taught to remain the authors, critics, and responsible owners of their own judgments. The future of independent thinking will depend less on the presence of AI in classrooms than on the educational choices made around it.

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Student Perceptions of Traditional, IT-Based, and Blended Teaching Methods in Pharmaceutical Botany: A Questionnaire-Based Study

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Abstract

This study investigates the current status and reform pathways of teaching in Pharmaceutical Botany, a core discipline for Chinese Materia Medica majors that integrates theoretical knowledge with practical identification. An online questionnaire surveyed 81 undergraduates at a Guizhou medical university, assessing initial interest, prior experience, perceptions of traditional and IT-based formats, and comparative advantages. Results indicate that 71 students (87.65%) expressed initial interest in the course, and 72 students (88.89%) had prior field or cultivation experience. Traditional hands-on sessions, including specimen observation, microscopy, and field internships, received endorsement from over 90% of respondents but faced temporal, spatial, and resource constraints. IT-based methods were valued for flexibility and rich information yet criticized for lacking authentic sensory experiences and causing cognitive overload. Most respondents (61 students, 75.31%) preferred a deep integration of both. Based on these findings, the study proposes a student-centered blended framework synergistically combining virtual and real elements, advocating strengthened offline practice with strategic digital integration to enhance comprehension, practical competence, and autonomous motivation.

Keywords: Pharmaceutical Botany; teaching approach reform; blended teaching; traditional teaching; modern information technology

1. Introduction

Pharmaceutical Botany constitutes a foundational and indispensable course within the Chinese Materia Medica undergraduate curriculum. It encompasses the morphological characterization, anatomical structure, taxonomic classification, and medicinal value of plant

species, thereby bridging fundamental botanical science with clinical pharmacy applications. The content scope of the course is relatively broad and inherently interdisciplinary, covering plant cell biology, tissue organization, organ morphology, systematic taxonomy, phytochemistry, and ethnopharmacological uses. This knowledge base is not only theoretically dense but also highly practice-oriented, requiring students to develop both conceptual understanding and operational proficiency in plant identification and quality evaluation.

At the undergraduate level, students typically enroll in this course during their sophomore year, having recently transitioned from the predominantly receptive learning models of secondary education. While they may possess rudimentary knowledge of plant biology—such as basic cell structure, tissue types, and organ functions—this prior knowledge often proves inadequate for the integrated and systematic demands of Pharmaceutical Botany. The subject matter is inherently abstract, involving microscopic anatomical features and complex taxonomic terminology, and its successful mastery depends on the learner's ability to synthesize information from multiple sub-disciplines.

To date, pedagogical approaches in Pharmaceutical Botany have predominantly relied on a combination of teacher-centered lectures, laboratory demonstrations, and field practicums. Commonly reported methods include theory-practice integration (Sun et al., 2018), object-based or specimen-based teaching (Peng & Wang, 2010), extended course material sharing, questioning-based instruction (Sun et al., 2018), and discussion-oriented seminars (Wang et al., 2025). Despite the diversity of these techniques, the overall instructional paradigm remains largely teacher-dominated, wherein the instructor acts as the primary transmitter of knowledge while students assume a relatively passive role. This traditional model has been increasingly scrutinized

for its limited effectiveness in cultivating critical thinking, problem-solving skills, and long-term knowledge retention.

A growing body of educational research has critiqued the conventional lecture-based approach for failing to engage students as active participants in their own learning. Jony (2016) observed that teacher-centered instruction often marginalizes students' subjective agency, rendering them passive recipients of information and hindering their capacity for deep cognitive engagement. Similarly, Tsui (2008) suggested that rote memorization and one-way transmission of knowledge impede the formation of interconnected mental schemas, thereby preventing learners from grasping the intrinsic relationships among disparate concepts and ultimately fostering superficial, mechanistic reasoning. Moreover, recent studies have highlighted persistent inadequacies in both the content delivery and practical training components of Pharmaceutical Botany curricula, suggesting that piecemeal reforms are insufficient and that a more systemic reconceptualization of teaching approaches is urgently needed (Meng et al., 2026).

Given the multifaceted and experiential nature of botanical study, we contend that the optimal starting point for pedagogical reform lies not in top-down institutional mandates but in a bottom-up understanding of student perspectives. Learners, as the primary agents of the educational process, possess unique insights into which instructional methods resonate with their cognitive styles, motivational drivers, and practical needs. Therefore, the present study adopts a student-centered methodological stance, seeking to elicit and analyze students' authentic evaluations of existing teaching approaches, their preferences for alternative formats, and their perceptions of the relative merits and drawbacks of traditional versus modern IT-based pedagogy. By grounding the reform agenda in empirical evidence derived from the student body, we aim to offer actionable

recommendations that are both theoretically informed and practically feasible.

To this end, we conducted a comprehensive online survey among 81 undergraduates enrolled in Pharmaceutical Botany at a regional medical university in Guizhou Province. The survey instrument was designed to capture multiple dimensions: initial students' initial interest, prior practical exposure, experiential assessments of specific teaching forms, comparative advantage/disadvantage rankings, and overall preference for future instructional models. The resulting dataset provides a valuable preliminary empirical evidence for diagnosing current pedagogical challenges and charting a nuanced path toward blended, student-responsive teaching that harmonizes the strengths of traditional hands-on methods with the affordances of digital technologies.

2. Methods

2.1 Survey Context and Participants

The survey was conducted at a medical university situated in Guizhou Province, southwestern China, which is characterized by rich biodiversity and a long-standing tradition of medicinal plant utilization. The participants were undergraduate students enrolled in the Chinese Materia Medica program, all of whom were required to complete the Pharmaceutical Botany course as a core component of their professional training. A total of 81 students voluntarily participated in the survey, comprising 2 freshmen, 61 sophomores, and 18 juniors. The distribution reflects the typical cohort structure, with the majority of students at the sophomore stage when the course is normally offered. All participants had previously received basic instruction in general botany and had some exposure to plant identification through their pre-university education or extracurricular

activities.

2.2 Survey Instrument and Procedure

The survey was administered online using a widely accessible mobile platform, allowing students to complete the questionnaire at their convenience and ensuring anonymity to encourage candid responses. The instrument was structured into three distinct sections, each designed to probe a specific domain of inquiry.

Part I collected demographic and baseline information, including academic year, prior field internship or cultivation experience related to medicinal plants, and self-reported level of interest in Pharmaceutical Botany prior to course commencement. This section comprised four single-choice items.

Part II focused on students' experience and preference regarding specific teaching approaches. It included six multiple-choice items that presented both traditional (e.g., teacher-led lecturing, specimen observation, microscopic examination, field internships, taxonomic key usage) and modern IT-based formats (e.g., online courses/micro-lectures, digital herbaria/databases, digital slides, virtual simulation experiments, interactive smart classrooms). For each format, participants rated their level of favorability on a five-point Likert-type scale ranging from "very unfavorable" to "very favorable."

Part III addressed comparative evaluations and open-ended suggestions. This section contained four items, three of which were single-choice (overall preference between traditional, modern, or blended models; optimal combination within blended teaching; and perceived learning outcomes enhanced by blended teaching) and one open-ended item soliciting additional comments

or alternative proposals.

2.3 Data Processing and Analytical Approach

For single-choice items, percentages were computed as the proportion of respondents selecting a particular option relative to the total number of respondents. For multiple-choice items, percentages were calculated as the number of times an option was selected divided by the total number of respondents, allowing for multiple selections per participant. All percentage values were rounded to two decimal places to maintain precision while avoiding unnecessary granularity.

To facilitate interpretability and comparative analysis, responses from the five-point preference scales (Part II, items 5 and 8) were collapsed into three aggregated categories: "popular" (combining "somewhat favorable" and "very favorable"), "indifferent" (neutral), and "unpopular" (combining "very unfavorable" and "somewhat unfavorable"). This trichotomous classification simplifies cross-form comparisons while preserving the directional valence of student attitudes. All survey responses were voluntary, and the raw data were recorded in a de-identified format to protect participant privacy. Descriptive statistics and frequency distributions were generated using standard spreadsheet software, with no inferential statistical tests applied, as the study's primary aim was to map prevailing perceptions rather than to test causal hypotheses.

3. Results

3.1 students' initial interest and Prior Experience

Among the 81 respondents, 72 students (88.89%) reported having prior field internship or cultivation experience related to medicinal plants (Figure 1B), indicating that students enter the

course with a tangible connection to the subject matter. Only 9 students (11.11%) had no such background (Figure 1B). In terms of interest level, 18 students(22.22%) indicated they were "very interested" in Pharmaceutical Botany before instruction began, while 53 students (65.43%) were "somewhat interested," 9 students (11.11%) were neutral, and a mere 1 student (1.23%) was "not very interested", No student selected "very uninterested" (Figure 1A). These data indicate that overall students' initial interest is relatively high (87.65% combining "very" and "somewhat interested"), and that the vast majority of students already possess a foundational practical exposure that can be leveraged to enhance learning engagement.

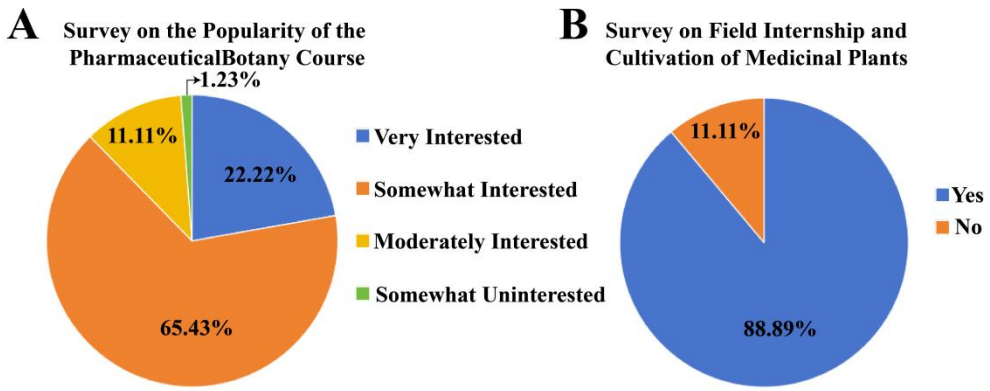


Figure.1. Survey on students' pre-course interest and prior experience before instruction. (A) Analysis of students' students' pre-course interest; (B) Analysis of prior field or cultivation experience.

3.2 Experience and Preference for Teaching Approaches

Students' experiential evaluations of teaching approaches are critical indicators of instructional effectiveness, as positive learning experiences have been shown to enhance motivation and sustained engagement, while preference patterns directly influence course interest and academic perseverance (Petrescu & Benta, 2023). In this study, we systematically assessed both traditional

and modern IT-based teaching formats, each comprising five representative forms.

Traditional teaching formats included: (a) teacher-led systematic lecturing; (b) observation of physical specimens; (c) microscopic observation of plant tissue sections; (d) field internships and specimen collection; and (e) plant identification using taxonomic keys (Song et al., 2015; Ji et al., 2012; Zhang et al., 2007). Modern IT-based formats encompassed: (a) online courses and micro-lecture videos (Huang et al., 2018); (b) digital herbarium and online databases (Liu et al., 2021); (c) digital slides (Wang et al., 2021); (d) virtual simulation experiments or simulated field internships (Yan et al., 2021); and (e) interactive smart classrooms (Song & Guo, 2024).

As presented in Table 1, the favorability rates (combined "somewhat favorable" and "very favorable") for traditional approaches were uniformly high: teacher-led lecturing reached 60 students (74.07%); specimen observation achieved 74 students (91.36%); microscopic section observation stood at 76 students (93.83%); field internships and specimen collection peaked at 77 students (95.06%); and taxonomic key identification recorded 63 students (77.77%). Notably, the three practical hands-on formats (specimen observation, microscopy, and field internships) all exceeded 90% favorability, underscoring the substantial student appreciation for authentic, tactile learning experiences. The neutral ("indifferent") proportions ranged from 9 students (11.11%) to 25 students (30.86%), while unpopular responses were minimal, never exceeding 6 students (7.4%).

Table 1.Evaluation of Student Experience and Preferences for Traditional Teaching Approaches.

Teaching Approach	Very Unfavorable	Somewhat Unfavorable	Neutral	Somewhat Favorable	Very Favorable

Teacher-led systematic lecturing	1.23%(1)	1.23%(1)	30.86%(25)	54.32%(44)	19.75%(16)
Observation of physical specimens	2.47%(2)	0.00%(0)	12.35%(10)	45.68%(37)	45.68%(37)
Microscopic observation of plant tissue sections	1.23%(1)	0.00%(0)	11.11%(9)	51.85%(42)	41.98%(34)
Field internship and specimen collection	1.23%(1)	0.00%(0)	12.35%(10)	44.44%(36)	50.62%(41)
Plant identification via taxonomic keys	1.23%(1)	6.17%(5)	23.46%(19)	44.44%(36)	33.33%(27)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

For modern IT-based approaches (Table 2), favorability ratess were also substantial: online courses/micro-lectures garnered 51 students (62.97%); digital herbaria/databases reached 64 students (79.01%); digital slides achieved 64 students (79.02%); virtual simulation field internships were favored by 68 students (83.95%); and interactive smart classrooms obtained 57 student (70.37%). Across all modern formats, the popular proportion consistently exceeded the neutral and unpopular categories, though the neutral share was noticeably higher than in traditional practical formats, particularly for online courses, where 27 students (33.33%) were neutral. This suggests that while students generally appreciate the affordances of digital technologies, a notable minority segment remains ambivalent or uncertain about their effectiveness.

Table 2.Evaluation of Student Experience and Preferences for Modern Information -Technology-Based Teaching Approaches.

Teaching Approach	Very Unfavorable	Somewhat Unfavorable	Neutral	Somewhat Favorable	Very Favorable

Online courses / micro- lecture videos	2.47%(2)	6.17%(5)	33.33%(27)	41.98%(34)	20.99%(17)
Digital herbarium / online databases	1.23%(1)	0.00%(0)	25.93%(21)	45.68%(37)	33.33%(27)
Digital slides	1.23%(1)	0.00%(0)	23.46%(19)	50.62%(41)	28.40%(23)
Virtual simulation experiments or field internships	1.23%(1)	1.23%(1)	17.28%(14)	40.74%(33)	43.21%(35)
Interactive smart classrooms	1.23%(1)	3.70%(3)	30.86%(25)	46.91%(38)	23.46%(19)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

3.3 Perceived Advantages and Disadvantages of Traditional vs. Modern Approaches

To gain a deeper understanding of the underlying reasons for students' preferences, we asked participants to identify the main advantages and disadvantages of both teaching paradigms. For traditional teaching, students were presented with a list of potential strengths and limitations and asked to select all that applied.

As displayed in Table 3, the most highly endorsed advantage of traditional teaching was its intuitive and authentic nature (e.g., touching specimens, conducting fieldwork), selected by 65 students (80.25%) of respondents. The second most cited strength was the systematic knowledge framework and clear logic (59 students, 72.84%), followed by direct teacher-student interaction and an active classroom atmosphere (47 students, 58.02%), and the cultivation of solid foundational skills and hands-on ability (37 students, 45.68%). No other advantages were mentioned.

Table 3.Advantages of Traditional Teaching Methods.

Options	Percentage
Intuitive and authentic, leaving a strong impression (e.g., touching specimens, field work)	80.25%(65)
Systematic knowledge framework, clear logic	72.84%(59)
Direct teacher-student interaction, clear and active atmosphere	58.02%(47)
Helps to cultivate solid basic skills and hands-on ability	45.68%(37)
Others	0.00%(0)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

Conversely, the main disadvantages of traditional teaching (Table 4) were dominated by severe constraints of time, space, and weather, particularly for field-based activities (63 students, 77.78%). Limited teaching resources, such as insufficient specimen availability (52 students, 64.20%), and relatively fixed content that lacks vividness (36 students, 44.44%) were also prominent. 30 students (37.04%) reported difficulty in re-watching or re-experiencing the learning process, especially for demonstrations and blackboard work.

Table 4.Disadvantages of Traditional Teaching Methods.

Options	Percentage
Severe constraints by time, space, and weather (e.g., field internships)	77.78%(63)
Limited teaching resources (e.g., specimens)	64.20%(52)

Content relatively fixed and not vivid enough	44.44%(36)
Difficulty in re-watching/re-experiencing (e.g., teacher's blackboard writing, operational demonstrations)	37.04%(30)
Others	0.00%(0)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

For modern IT-based teaching, the perceived advantages (Table 5) were largely associated with flexibility and resource richness. The most frequently cited advantage was rich resources and large information volume, including access to databases (74 students, 91.36%), followed by flexible learning time and location with repeatability (70 students, 86.42%). Novel and attractive forms (58 students, 71.60%) and strong interactivity with timely feedback (22 students, 27.16%) were also acknowledged, though the latter was less widely endorsed.

Table 5.Advantages of Modern Information-Technology-Based Teaching Approaches.

Options	Percentage
Flexible learning time and location, repeatable learning	86.42%(70)
Rich resources and large information volume (e.g., databases)	91.36%(74)
Novel forms, vivid and interesting, highly attractive	71.60%(58)
Strong interactivity and timely feedback (e.g., classroom polling)	27.16%(22)
Others	0.00%(0)

Note: The numbers in parentheses in the table indicate the number of students who selected this

option.

However, the disadvantages of modern IT-based approaches (Table 6) were also clearly articulated. The most serious drawback was the lack of authentic sensory experiences—tactile, olfactory, and other somatic perceptions—cited by 58 students (71.60%). Information overload and easy distraction followed closely at 52 students (64.20%), while over-reliance on devices and networks was noted by 41 students (50.62%). Additionally, 33 students (40.74%) expressed concern about potential reduction in face-to-face emotional communication between teachers and students. A small proportion (2 students, 2.47%) mentioned other disadvantages, such as technical glitches or eye strain.

Table 6.Disadvantages of Modern Information-Technology-Based Teaching Approaches.

Options	Percentage
Over-reliance on devices and networks	50.62%(41)
Lack of authentic tactile, olfactory, and other sensory experiences	71.60%(58)
Information overload, easily distracted	64.20%(52)
Potential reduction in face-to-face emotional communication between teachers and students	40.74%(33)
Others	2.47%(2)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

Collectively, these comparative data reveal that traditional and modern approaches possess complementary strengths and weaknesses. Traditional teaching excels in providing authentic, systematic, and interactive learning experiences, whereas modern IT-based teaching offers

flexibility, rich information, and repeatability. Their respective advantages effectively compensate for the other's deficiencies: for instance, digital tools can overcome spatial and temporal limitations of field trips, while hands-on activities can restore the sensory authenticity that virtual environments lack.

3.4 Overall Preference and Optimal Blended Model in the Pharmaceutical Botany Course

After evaluating individual teaching formats and their pros and cons, we asked students to declare their overall preference among three broad instructional models: (a) mainly traditional, (b) mainly modern IT-based, or (c) deep integration of both (i.e., blended online-offline teaching). As shown in Table 7, 61 students (75.31%) chose the integrated blended model, while only 12 students (14.81%) preferred traditional methods alone and 8 students (9.88%) favored IT-based methods exclusively. This substantial majority indicates a notable student consensus in favor of pedagogical hybridization.

Table 7.Survey on Students' Preferences for Teaching Methods.

Options	Percentage
Mainly rely on traditional teaching methods	14.81%(12)
Mainly rely on modern information technology teaching methods	9.88%(8)
Deep integration of both (online and offline blended teaching)	75.31%(61)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

Furthermore, when asked to specify the ideal combination within a blended framework

(Table 8), the most popular choice was "offline classroom delivery of core knowledge, with online platform used for extended resources, submitting assignments and quizzes," selected by 47 students (58.02%) of respondents. The alternative model—"online learning of theoretical knowledge (videos, materials), with offline classroom discussions, Q&A, and experimental operations"—received 32 students (39.51%) support, while a mere 2 students (2.47%) proposed other combinations. These results suggest that students favor a structure where foundational concepts are introduced in person, while supplementary materials and formative assessments are delivered digitally, rather than fully flipping the classroom.

Table 8.Survey on the Optimal Combination for Blended (Online-Offline) Teaching Mode.

Options	Percentage
Online learning of theoretical knowledge (videos, materials), with offline classroom discussions, Q&A, and experimental operations	39.51%(32)
Offline classroom teaching of core knowledge, with online platform used for extended resources, submitting assignments and quizzes	58.02%(47)
Other combination suggestions (please briefly explain)	2.47%(2)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

Finally, we queried students about which specific learning outcomes they believed would be most enhanced by adopting a blended teaching approach (Table 9). The highest proportion (27 students, 33.33%) pointed to memorization and understanding of theoretical knowledge, followed by learning interest and initiative (23 students, 28.40%) and practical operation and appraisal skills

(20 students, 24.69%). Comprehensive problem-solving ability and teamwork/communication skills were less frequently mentioned (10 students, 12.35% and 1 student, 1.23%, respectively). This pattern implies that students perceive blended teaching primarily as a tool for consolidating theoretical content and boosting motivation, rather than as a direct solution for higher-order competencies—though they do not dismiss its potential for the latter.

Table 9.Survey on the Learning Outcomes Enhanced by Adopting a Blended (Online-Offline) Teaching Mode.

Options	Percentage
Memorization and understanding of theoretical knowledge	33.33%(27)
Practical operation and appraisal skills	24.69%(20)
Learning interest and initiative	28.40%(23)
Comprehensive ability to solve complex problems	12.35%(10)
Teamwork and communication skills	1.23%(1)

Note: The numbers in parentheses in the table indicate the number of students who selected this option.

4.Discussion

The present study, through a comprehensive survey of 81 undergraduates, has systematically studied the current student perceptions, experiences, and preferences regarding the teaching approaches employed in Pharmaceutical Botany. The findings not only confirm the enduring appeal of hands-on, experiential learning but also illuminate the emerging demand for technology-enhanced flexibility. In this section, we interpret the results in light of existing literature,

discuss their pedagogical implications, and propose a coherent framework for reforming the course.

4.1 High students' initial interest and the Advantage of Prior Experience

A notable finding is the relatively high level of student interest in Pharmaceutical Botany prior to formal instruction, with 71 students (87.65%) expressing positive interest (Figure 1A). The elevated interest may be attributed to the inherently tangible and aesthetically appealing nature of plants, as well as the cultural and economic significance of medicinal herbs in the Chinese context. Moreover, the fact that 72 students (88.89%) had prior field or cultivation experience suggests (Figure 1B) that informal exposure—through family traditions or school gardens—has already cultivated a degree of familiarity and curiosity. This finding has important implications for instructional design: educators can leverage students‘ existing knowledge and personal connections to the subject matter to channel their initial enthusiasm into systematic learning.

4.2 The Irreplaceable Role of Traditional Hands-On Methods

The practical components of traditional teaching were recognized by the majority of students—with specimen observation, microscopy, and field internships all exceeding 90% favorability (Table 1)—underscores a fundamental principle of botanical pedagogy: authentic sensory engagement is widely considered irreplaceable. The tactile experience of handling plant specimens, the visual scrutiny of cellular details under a microscope, and the immersive context of field exploration together create rich cognitive and affective impressions that digital simulations, however sophisticated, cannot fully replicate. Students' own articulation of the main advantage of traditional teaching as "intuitive and authentic" (65 students, 80.25%) reinforces this interpretation (Table 3).

Nevertheless, students were equally articulate about the limitations of traditional methods. The constraints of time, space, weather, and limited teaching resources are practical barriers that have long plagued field-based education. In an era of expanding class sizes and shrinking contact hours, relying solely on conventional fieldwork can hardly meet the teaching needs. The fact that 52 students (64.20%) cited "limited teaching resources" suggests that even within traditional settings, resource inadequacy (Table 4)—such as insufficient specimen or outdated microscope slides— diminishes the learning experience. Thus, while traditional approaches are valued, they are also recognized as having certain limitations when used alone.

4.3 The Affordances and Pitfalls of Modern IT-Based Teaching

Modern IT-based teaching approaches were generally well received, particularly for their flexibility and informational abundance. The high endorsement of "rich resources and large information volume" (74 students, 91.36%) and "flexible time and location, repeatable learning" (70 students, 86.42%) (Table 5) indicates that students appreciate the ability to access learning materials on demand and revisit difficult concepts at their own pace. Digital herbaria and online databases, in particular, provide a favorable platform for accessing rare or geographically distant specimens, thereby making knowledge of pharmaceutical botany more accessible.

However, the significant criticisms leveled at IT-based teaching—notably the lack of authentic sensory experiences (58 students, 71.60%) and information overload leading to distraction (52 students, 64.20%) (Table 6)—highlight the inherent trade-offs of digitization. The absence of tactile, olfactory, and even auditory cues that accompany real plants can reduce the richness of perceptual learning, which is critical for accurate identification and classification. Furthermore, the

sheer volume of online content can overwhelm students, leading to superficial browsing rather than deep processing. Moreover, 33 students (40.74%) who worried about diminished emotional communication (Table 6) between teachers and students point to the relational dimension of teaching—a dimension that is often undervalued in technology-centric reform discourses.

4.4 The High Endorsement for Blended Teaching

A notable outcome of this survey is 61 students (75.31%) preference for a deep integration of traditional and modern approaches (Table 7). What is particularly informative is the specificity of students' preferences: they favor a model where core knowledge is delivered offline, while online platforms serve as repositories for supplementary resources, assignments, and quizzes (Table 8). This suggests that students prefer to enhance the classroom experience rather than replace it entirely.

This preference also implies that traditional teaching methods and modern IT-based approaches each have their own strengths. A deep integration of the two can help preserve the role of the instructor as a facilitator and mentor, while empowering students to take greater ownership of their learning process. The fact that 47 students (58.02%) chose this combination, compared to 32 students (39.51%) for the flipped alternative (Table 8), suggests that students are cautious about placing too much cognitive load on self-directed online study, especially for a subject as visually and conceptually complex as botany.

4.5 Implications for Teaching Reform

Based on these findings, we propose a multi-pronged reform strategy for Pharmaceutical Botany that is student-centered, evidence-informed, and context-sensitive.

First, theoretical knowledge that is highly repetitive or rule-based—such as plant cell structure, tissue types, and systematic terminology—can be effectively digitized into short micro-lectures, animated diagrams, and interactive quizzes. These resources should be made available online for students to access before or after class, thereby freeing classroom time for more interactive and applied activities.

Second, the core practical components—specimen observation, microscopic identification, and field internships—should be preserved and even strengthened in the offline curriculum. Rather than reducing these sessions, institutions should invest in maintaining specimen collections, upgrading microscopy facilities, and securing field sites. The authenticity of these experiences is the unique value proposition that cannot be outsourced to digital alternatives.

Third, digital tools should be strategically deployed to address the limitations of traditional methods. For instance, digital herbaria and virtual simulation experiments can serve as preparatory activities before field trips or as remedial tools for students who miss fieldwork due to illness or weather cancellations. They can also provide supplementary visualizations—such as 3D reconstructions of plant anatomy—that enhance comprehension of complex structures.

Fourth, interactive smart classroom technologies—such as real-time polling, collaborative annotation, and discussion bulletins—can be introduced to boost participation and foster a more dialogic learning environment. These tools are particularly valuable for large classes where individual students may hesitate to speak up.

Fifth, assessment and feedback mechanisms should be redesigned to align with the blended model. Online quizzes and peer-evaluation platforms can provide immediate formative feedback,

while offline practical examinations can assess hands-on proficiency. The combination allows for continuous, low-stakes assessment that reduces examination anxiety and promotes sustained engagement.

4.6 Limitations and Future Research

While this study provides valuable empirical insights, it is not without limitations. The sample is drawn from a single institution in a specific geographic region, which may limit generalizability to other contexts with different student demographics, resource endowments, or curricular structures. Moreover, the survey relied on self-reported perceptions rather than objective measures of learning outcomes; future studies should triangulate these findings with performance data, such as examination scores or practical skill assessments. Additionally, the study is cross-sectional in design; longitudinal research tracking student responses before, during, and after the implementation of blended reforms would offer stronger evidence of causality.

Nonetheless, the current findings offer an evidence base for designing and piloting blended teaching interventions in Pharmaceutical Botany. We encourage educators to adopt an iterative, action-research approach: implement incremental changes, gather student feedback, and refine the model accordingly. By doing so, the course can evolve into a dynamic, responsive educational experience that meets the diverse needs of contemporary learners while preserving the disciplinary rigor and authenticity that define botanical science.

5. Conclusion

This study has empirically examined the perceptions, experiences, and preferences of undergraduate Chinese Materia Medica students regarding traditional and modern IT-based

406 teaching approaches in Pharmaceutical Botany. The results suggest that while students highly value
407 the authenticity and systematicity of traditional hands-on methods, they also recognize and
408 appreciate the flexibility and informational richness of digital technologies. However, neither
409 approach in isolation fully satisfies their learning needs; instead, a substantial majority of students
410 (61 students, 75.31%) explicitly endorse a deep integration of both—a blended online-offline
411 teaching model.

412 The preferred configuration articulated by students—core knowledge delivered offline,
413 supplemented by online platforms for extended resources, assignments, and quizzes—aligns with
414 contemporary blended learning theories. This approach offers a pragmatic pathway that preserves
415 the valuable experiential dimension of botanical education while leveraging the flexibility and
416 informational richness of digital technologies.

417 In practical terms, the teaching strategy for Pharmaceutical Botany should be optimized.
418 Online platforms can be reasonably used for theoretical learning. Practical sessions (specimen
419 observation, microscopy, fieldwork) should be preserved and strengthened. Digital resources can
420 help overcome spatiotemporal constraints. Interactive classroom technologies should be integrated
421 to foster active student participation. Although further research with objective learning outcomes
422 and larger, multi-institutional samples is needed, this study provides preliminary evidence for
423 integrating traditional and IT-based approaches in Pharmaceutical Botany.

424 Ultimately, pedagogical reform in Pharmaceutical Botany should not be framed as a binary
425 choice between tradition and modernity. Rather, it should be conceived as a synergistic
426 integration—a "virtual-reality complementarity"—that places students at the center, respects the

discipline's unique requirements, and responds to the evolving technological landscape. This approach may help educators cultivate not only skilled practitioners of medicinal plant identification but also lifelong learners equipped with critical thinking, practical competence, and enduring curiosity.

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