International Journal of Education and Social Development
ISSN: 3078-9931 (Print), ISSN: 3078-2287 (Online) | Vol. 9, No. 1, 2026

The "Heavy Technology, Light Mechanism" Dilemma in the Digital Transformation of Liberal Arts Laboratories and Its Resolution

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Abstract: Digital transformation has provided new momentum for the construction of liberal arts laboratories in universities, yet it commonly presents a gap of "technology deployed but application underperforming." This paper argues that the crux lies not in insufficient technology supply, but in an imbalance between the technological and the institutional dimensions: the disconnection between construction and use, the incentive mismatch between one-time and ongoing investment, and the collection of data without a decision-making loop. These three causal chains together constitute the structural dilemma of "heavy technology, light mechanism." Accordingly, this paper proposes demand frontloading with post-use evaluation, use-oriented performance assessment, and accountability systems with data-driven decision loops, so as to convert technological investment into sustained application effectiveness.

Keywords: Liberal arts laboratory; digital transformation; application effectiveness; operational mechanism.

1. Problem Statement

The integration of artificial intelligence, big data, and other technologies with education is driving digital transformation in universities. As practice sites for talent cultivation, liberal arts laboratories serve as key platforms for fostering students' innovative and practical abilities as well as interdisciplinary perspectives. In April 2025, the Ministry of Education and eight other departments jointly issued the *Opinions on Accelerating the Digitalization of Education*, calling for digital empowerment to promote holistic reform of educational philosophy, teaching models, and educational governance. Under this policy guidance, universities have steadily advanced the digital transformation of laboratories. In practice, however, problems such as "heavy construction but light operation," insufficient resource integration, ambiguous experimental paradigms, weak team building, and uneven data quality with lagging management have emerged repeatedly. Their root cause lies in the separation between laboratory construction and institutional development.

In recent years, scholars have conducted extensive research on the construction of liberal arts laboratories. Regarding the essence and positioning of liberal arts laboratories, the academic community has moved from functional description to the level of paradigm transformation. Xie Zhitao, drawing on evidence-based theory, argues that liberal arts laboratories carry the functions of interdisciplinary integration and service to national strategies, and that their construction must connect the three stages of "starting point, process, and outcome" through a "chain of evidence" [1]. Zhao Xianghui and Cheng Feiya, based on a typological multi-case study, further define liberal arts laboratories as "a new type of research organization advancing paradigm innovation in humanities knowledge production," whose core features lie in the integration of physical and virtual spaces, dual innovation of experimental paradigms, and foundational support from data resources [2]. Tang Bin, tracing the trajectory of the "new liberal arts turn," points out that philosophy and social science laboratories are undergoing a shift from technology transplantation to contextual reconstruction [3]. It follows that the value of liberal arts laboratories now extends beyond the role of a mere "auxiliary venue for experimental teaching," pointing instead toward a paradigm transformation in liberal arts research.

On this basis, the analysis of dilemmas constitutes the focus of existing research. Ji Yilong and Zhang Mingzhuo propose a "prospect–dilemma–pathway" analytical framework, summarizing the practical challenges of digital transformation as closed construction models, lagging teaching models, subjective research paradigms, and insufficient teacher digital literacy, and respond with a "four new" pathway [4]. Chen Xiancai and Ke Li introduce the multiple streams framework to analyze the obstacles to new liberal arts laboratory construction from three dimensions—the problem stream, the policy stream, and the political stream [5]. Yang Ning and Qin Feng focus on the data dimension, noting that liberal arts laboratories are shifting from equipment management toward a data-asset-centered governance model, whose crux lies in data dispersion, lack of quality standards, and insufficient privacy protection [6]. Collaborative sharing mechanisms have thus become the entry point for resolving these dilemmas. Yang Yang argues that liberal arts laboratory governance is a multi-dimensional interactive process spanning levels, actors, and domains, with collaborative sharing constituting the core of its operational mechanism [7]. Cheng Feiya and Zhao Xianghui, through cases at Cambridge, Harvard, and Yale, distill three types of interdisciplinary collaboration mechanisms: deep-integration, matrix-coordination, and open-network [8]. Based on an analysis of 32 humanities and social science laboratories at top American universities, Qu Liaojian identifies high organizational consistency, strong academic autonomy, and strong digital technology application as their operational features, while also noting challenges such as the split between technology and theory and the misalignment of interdisciplinary collaboration [9].

In sum, existing research has formed a relatively systematic understanding of the connotation, dilemmas, and governance

pathways of liberal arts laboratories, yet it largely focuses on the "construction side" and leaves insufficiently addressed the operational-mechanism question of "why technological investment fails to translate into sustained application." This study focuses on one question: platform construction has solved "whether it can be used," but management mechanisms have not kept pace—what are the institutional and cognitive roots of this gap, and how should future construction pathways be optimized?

2. Problems and Causes in Liberal Arts Laboratories

2.1. Major Problems

As important carriers of the "new liberal arts" initiative, liberal arts laboratories bear the mission of advancing paradigm innovation in humanities knowledge production and promoting interdisciplinary integration. Nevertheless, they still face numerous challenges amid rapid development.

Built but unused: construction completed while application remains unrealized. The construction of liberal arts laboratories generally ends with compliance-based acceptance: platform construction focuses mainly on whether system functions are complete, and acceptance checks whether equipment has arrived and modules are operational, while whether anyone actually uses the laboratory after completion—and how well it is used—falls outside the scope of assessment. Consequently, laboratories complete their construction in form yet remain idle in operation. Zhang Qi and colleagues, examining liberal arts laboratories at foreign universities, point out that world-class universities position such laboratories as organizational hubs for knowledge integration and interdisciplinary collaboration, whereas domestic liberal arts laboratories largely remain at the level of teaching support [10]. Equipment integrity rates approach full marks while usage data remain blank—this gap between construction outcomes and usage status is pervasive in liberal arts laboratories.

Heavy construction, light operation: hardware investment continues while operation goes unclaimed. Funding for liberal arts laboratories is heavily concentrated in one-time stages such as equipment procurement and system construction, with dedicated line items for equipment and software fees, whereas the operational funding and dedicated positions needed to sustain ongoing system operation remain long absent. As a result, more and more equipment is purchased while supporting management and operation lag behind: after systems go online, there is no dedicated maintenance staff, and reservations, resources, and data are left unattended, making it difficult for usage to become routine. Hu Feifei points out that the transformation of liberal arts laboratory achievements already faces the dilemma of blocked channels and missing mechanisms [11]; the imbalance between hardware investment and operational support further aggravates this problem.

Data collected but unused: data accumulate yet fail to enter decision-making. The digital systems of liberal arts laboratories accumulate large amounts of ledger and scheduling data, but these data mostly stop at archival retention and are not converted into a basis for resource allocation and management improvement. Ledgers are considered complete once accounts match, reservation records are shelved once entered into the system, and data across departments use inconsistent standards that are difficult to aggregate. Su Xin and colleagues note that university laboratory data governance generally faces common problems such as a weak foundation for data collection, data management failing to meet operational needs, insufficient construction of data application systems, and underexploited data value [12]. Jiang Guiyou's analysis of 26 university computational social science laboratories worldwide likewise indicates that digital-age liberal arts knowledge production requires assessment accountability to achieve quality control [13]; the absence of this link leaves data stranded at "collection" and unable to reach "application."

2.2. Causes of These Problems

Disconnection between construction logic and use logic. The crux of liberal arts laboratories lies in the fact that construction and use are driven by two different logics and belong to two different sets of actors. Construction is driven by compliance-based acceptance, with project approval and acceptance both focused on whether the system is up and running and whether its functions are complete; use is driven by the needs of user departments, with teachers concerned about whether the environment can support their courses and students about whether resources are available. The builders are information technology and equipment management departments, while the users are teachers and students—two groups belonging to different organizational sequences, with no connection between builders and users during the construction phase. Systems are deemed complete once they meet acceptance standards; whether anyone uses them and whether they work well is outside the scope of acceptance.

The outputs of liberal arts laboratories—data accumulation, methodological training, interdisciplinary collaboration, and process-based competencies—are difficult to convert into quantifiable indicators such as papers, projects, and awards. In a current evaluation system that treats hard indicators as the currency, such outputs have no place, leaving liberal arts laboratories perpetually disadvantaged in the allocation of staffing, funding, and assessment quotas, with operational positions unallocated and operational funding unlisted. Consequently, "building without operating" becomes a rational choice for all actors under the existing incentive structure: construction yields one-time funding and counts toward administrative achievement, whereas operation requires sustained investment with no assessment reward. The disconnection between construction and use is therefore not negligence but a product of the incentive structure.

Incentive mismatch between one-time and ongoing investment. Equipment and software procurement is one-time, visible, and auditable; the building of operational positions, sharing rules, and usage assessment is ongoing, invisible, and difficult to audit, with long return cycles and outcomes that often fall to successors across administrative terms. Managerial performance within a term is judged by visible results within that term, so investing in mechanism building amounts to "doing favors for others." As a result, budgets have equipment funding year after year but no operational funding, and operational staff are mostly part-time teachers with neither responsibility nor incentive. The information silos and low utilization rates that persist across laboratory construction, management, and use share a common underlying cause: the absence of ongoing investment.

The root of this mismatch lies in the absence of accountability. Responsibilities in the construction phase are

clear—information departments build systems, equipment departments allocate funding, and departments manage laboratories—yet no one is accountable for usage rates in the use phase. Asset departments manage accounts, academic affairs departments manage scheduling, and information departments manage systems, but none of their responsibility boundaries covers "use." Without an accountable actor, there is no one to bear the burden of ongoing investment, and mechanism building is perpetually ranked behind equipment procurement, leaving resources unable to accumulate.

Data collected but no decision-making loop. Digitalization is supposed to bring usage data into management decisions, yet in practice it stops at "collection as the endpoint." Ledger and scheduling data serve only archival retention, neither identifying which laboratories sit idle nor determining where funding should go; departmental standards differ, and even aggregation at the university level is difficult. The break lies in the absence of a channel converting data into resource-allocation decisions: for usage data to take effect, it must enter assessment and funding allocation, yet current assessment focuses only on ledger accuracy and funding allocation only on equipment lists, leaving even complete and accurate data with nothing to attach to. A deeper layer is the dual absence of organizational capability and cognitive inertia for data-driven governance. Liberal arts laboratory managers are accustomed to "one-to-one supervision and paper records," lacking both the workflow of "identifying problems from data and adjusting resources accordingly" and the routine procedure of "data–deliberation–adjustment." Even with data at hand, few treat it as a basis for management. Data-driven governance cannot be obtained merely by installing a system; it requires managers to shift from "impression-based" to "data-based" judgment—a transformation that has yet to occur in the liberal arts laboratory context.

3. Resolution Pathways: Supplementing Mechanisms for Application Effectiveness

3.1. Demand Frontloading and Post-Use Evaluation: Bridging the Construction–Use Gap

The fundamental remedy for the construction–use disconnection lies in frontloading usage demand into construction decisions and feeding usage outcomes back into construction evaluation, so that construction no longer ends with "system launch" but with "put into use." At the university level, a governance loop of "demand frontloading—post-use evaluation" should be established. First, demand frontloading: make usage justification a mandatory step in project approval, requiring explicit specification of usage scenarios, user groups, and expected usage frequency, and withholding funding from projects without clear usage demand, thereby blocking "construction for construction's sake" at the source. Second, post-use evaluation: after completion and a period of operation, verify actual usage frequency and sharing scope against the usage expectations set at approval, and reduce subsequent investment or adjust the use of those laboratories that deviate significantly. The institutional design at both ends does not alter the complexity of the approval process; rather, it embeds the dimension of "use" into existing approval and acceptance systems, shifting the orientation of construction from "completing construction" to "realizing use."

3.2. Use-Oriented Performance Assessment Tailored to the Liberal Arts: Correcting the Incentive Mismatch of Ongoing Investment

Establish a use-oriented performance assessment capable of recognizing the value of liberal arts laboratories, making "using well" an assessable and rewarding endeavor. First, adapt the assessment yardstick to the liberal arts: rather than copying the science-and-engineering approach centered on instrument usage hours, measure the spatial, contextual, and resource value of liberal arts laboratories through sharing rate, usage frequency, and resource utilization rate. Second, put assessment results to effective use: incorporate them simultaneously into the assessment of schools and laboratory directors and into the next year's funding and staffing allocation—those with good usage receive priority investment, while those with poor usage have their funding reduced and their use adjusted. In this way, the returns on ongoing investment enter current-term assessment, correcting the "cross-term disadvantage" in incentive terms. To reduce resistance to implementation, a gradual strategy of "pilot first, then scale up" may be adopted, along with mechanisms for automatic data aggregation and anti-inflation of indicators to ensure the authenticity of assessment.

3.3. Accountability for Use and Data Decision Loops: Enabling Data-Driven Governance

Make usage accountable through clear responsibility, and make data effective through decision loops. At the responsibility level, universities should clarify the attributable responsibility in the use phase: the department overseeing laboratories bears overall responsibility for usage rates, departments are accountable for the application effectiveness of their own laboratories, and information departments ensure data interfaces, so that "underperforming application" has a responsible party. At the decision level, a data loop of "collection–analysis–decision–re-collection" should be established, allowing usage data to truly enter the reallocation of funding and resources. The realization of this loop depends, on the one hand, on unified indicator standards at the university level and departmental reporting of usage data so that performance across departments is comparable; and on the other, on internalizing "data-based judgment" as a managerial working style, elevating data-driven governance from a technical tool to a governance culture. Data involving student privacy must be handled through tiered authorization and the presentation of aggregate statistics only.

4. Conclusion

The digital transformation of liberal arts laboratories is not merely the informatization of these laboratories, but a transformation of management models, disciplinary innovation, and social services. By analyzing the roots of the problems in this transformation, this paper proposes concrete practical pathways in demand frontloading and post-use evaluation, use-oriented performance assessment, and accountability with data loops. Given limited capacity, the present study is based only on literature review and management practice across multiple universities, and still lacks systematic empirical verification; future work may combine application-effectiveness data from specific universities for further validation.

Acknowledgments

This work was financially supported by the Zhejiang Provincial Teaching Reform Project "Research on the Innovative Development of New Liberal Arts Laboratories in Universities Empowered by Artificial Intelligence in the Context of New Quality Education" fund

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