International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 25, No. 2, 2026

Capability Reconfiguration, Value Creation, and Implementation Paths of Digital Transformation in University Liberal Arts Laboratories

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Abstract: Artificial intelligence and big data are reshaping the research paradigm of the humanities and social sciences, and the digital transformation of university liberal arts laboratories has become a key component of the construction of the new liberal arts. Based on dynamic capabilities theory and public value theory, this paper constructs an analytical framework of "factor input–capability reconfiguration–value creation," addressing the question of which organizational capabilities transform digital technology investment into laboratory value and under what conditions this transformation holds. The study argues that the essence of digital transformation in liberal arts laboratories is capability reconfiguration rather than equipment renewal: digital technology investment can be converted into value only through data governance and the two functioning chains of knowledge production and open service, and public value constraints are the institutional conditions for the sustained creation of value. Accordingly, this paper proposes a transformation path centered on data resourceification, method integration, open collaboration, and evaluation reform.

Keywords: University Liberal Arts Laboratory, Digital Transformation, Dynamic Capabilities, Public Value, Capability Reconfiguration.

1. Introduction

The advent of the artificial intelligence era has brought fundamental changes to society's demand for talent, and laboratories, as the main front for talent cultivation, have become increasingly important. In 2023, the Ministry of Education issued the Administrative Measures for the Construction and Management of Philosophy and Social Sciences Laboratories in Higher Education Institutions (Trial), requiring laboratories to focus on the collection, accumulation, and tracking analysis of basic research data, emphasize innovation in research methods and the development of research tools, and encourage independent exploration of data-driven experimental techniques [1]. The Outline for Building a Strong Education Nation (2024–2035) further calls for "building sound philosophy and social sciences laboratories in universities" [2]. Liberal arts laboratories have thus become an important pillar of the new liberal arts initiative, serving both as a frontier platform for disciplinary innovation and as a key vehicle for enhancing students' practical and innovative abilities, fostering teamwork, and broadening their interdisciplinary horizons.

In laboratory construction, problems such as "emphasis on platform building over research integration," low levels of smart technology application, and the absence of an outcome evaluation system continue to constrain the development of liberal arts laboratories. Existing research focuses on digital transformation in higher education and has answered "what to build and how to build it." Wang et al. (2024), drawing on dynamic capabilities and resource orchestration theory, found that factors such as digital sensing, digital learning, digital innovation, and resource structuring, bundling, and leveraging jointly drive the digital transformation of universities in a multi-factor configuration, with uneven levels of transformation [3]. Hu and Jiang (2024) analyzed the digital transformation of education in the European Union from a public value perspective, depicting the transformation mechanism through the three dimensions of mission, politics, and operational management [4]. Ji and Zhang (2025) described the future prospects, dilemmas, and directions of the digital transformation of liberal arts laboratories and proposed a "sensing–connecting–computing–feedback" technical framework [5]; Su et al. (2023) proposed a data governance strategy for intelligent university laboratories based on information chain theory [6]. What existing research lacks is a mechanistic explanation connecting the two ends of "construction" and "paradigm"-that is, which organizational capabilities transform digital technology investment into value, under what conditions this transformation holds, and what public value constraints these capability choices are subject to.

This study, drawing on dynamic capabilities theory and public value theory, focuses on the value transformation mechanism in the digital transformation of liberal arts laboratories. By analyzing the process and conditions through which digital technology investment is converted into knowledge production value and public service value via organizational capabilities, it constructs an analytical framework and proposes corresponding implementation paths.

2. Theoretical Adaptation and Analytical Framework

2.1. Core Tenets of Dynamic Capabilities Theory and Public Value Theory

The concept of dynamic capabilities was proposed by Teece in 1994, referring to a firm's ability to integrate, build, and reconfigure internal and external capabilities to adapt to changes in the competitive environment [7]. It allows firms to build and renew organizational capabilities over resources and assets, reconfiguring and updating existing resources as needed to respond rapidly to changes in markets, business

environments, and technological opportunities. The dynamic capabilities framework encompasses sensing, learning, and innovating capabilities [3]. Sensing capability refers to identifying which research questions in the humanities can be made computable and grasping the direction of digital transformation; learning capability refers to researchers and computational staff updating methods and adjusting research designs through joint research; innovating capability refers to embedding computational methods into research processes and reshaping the mode of knowledge production itself. The transformation of liberal arts laboratories from "a space for storing equipment and materials" into "a data-driven knowledge production organization" is precisely the process of reconfiguring these three capabilities.

Public value theory originates from public management and addresses how organizations that spend public resources judge whether they have "done well." Moore argues that to create public value, public managers must simultaneously satisfy three conditions: value production (that what is done is valuable to the public), legitimacy and support (gaining recognition from the authorizing environment), and operational capability (possessing the capabilities and resources to achieve value goals) [8]. Laboratories are academic organizations funded by public money; their value cannot be measured by profit or output volume as in enterprises, but must be judged by asking for whom knowledge is created, who has the right to use it, and who bears the costs and risks. Accordingly, this paper operationalizes the judgment of public value into three tests: accessibility (who can use equipment and data), accountability (who bears costs and risks), and fairness (how resources, recognition, and benefits are distributed).

2.2. Adapting the Two Theories to the Digital Transformation of Liberal Arts Laboratories

The essence of digital transformation in liberal arts laboratories is capability reconfiguration rather than equipment renewal. To transform from "a space for storing equipment and materials" into "a data-driven knowledge production organization," a laboratory must rely not on how much equipment it acquires but on developing new organizational capabilities such as data governance, method integration, and open collaboration. This is exactly the process depicted by dynamic capabilities theory-transformation requires sensing capability (identifying computable research opportunities and judging the direction of transformation), learning capability (updating methods and adjusting designs through joint research), and innovating capability (embedding computational methods into research processes and reshaping the mode of knowledge production)-which is why dynamic capabilities theory can provide a process framework for this transformation.

Yet dynamic capabilities theory stops at "capability," and its outcome variable is competitive advantage, which cannot answer whether the transformation of a liberal arts laboratory is "good or bad." Liberal arts laboratories are academic organizations funded by public money, and their outputs-knowledge, data, and cultural services-are clearly public in nature: knowledge outcomes should be openly shared rather than privately monopolized, data assets concern individuals and society, and cultural services are vital to the transmission of civilization. These values cannot be measured by competitive advantage or output volume but must be judged by "for whom value is created, who legitimates it, and who bears the costs." Every capability choice in digital transformation is simultaneously a value choice-who has the right to use, who is recognized as a knowledge producer, and who bears costs and risks. Without public value constraints, capability building degenerates into an efficiency-oriented checklist; without capability building, value judgment becomes an externally imposed standard. The two theories therefore need each other in the digital transformation of liberal arts laboratories rather than being simply superimposed.

2.3. The "Factor Input–Capability Reconfiguration–Value Creation" Analytical Framework

Integrating the two theories of dynamic capabilities and public value, this paper constructs an analytical framework of "factor input–capability reconfiguration–value creation" (Figure 1).

The framework comprises three layers running from left to right, with public value constraints running throughout. The first layer is factor input: digital technology input (computing power, computing platforms, text mining, and large language model tools), humanities data (texts, archives, images, interviews, and field records), and human resources (researchers' digital methodological capability and a multidisciplinary technical team) constitute the three types of basic input for transformation. The organizational configuration of these three factors will not be realized automatically by input; it is precisely the process of capability reconfiguration.

The second layer is capability reconfiguration. The basic capability is data governance, which transforms scattered humanities materials into computable and reusable data assets through collection, description, annotation, rights confirmation, and ethical review. Dynamic capabilities manifest as sensing, learning, and innovating capabilities and, according to the direction of value, are divided into two functioning chains: first, the inward knowledge production chain oriented toward the discipline, which senses computable research opportunities, updates methods through joint research, and embeds computational methods into research processes, pointing toward knowledge production value; and second, the outward open service chain oriented beyond the organization, which senses demands such as policy advisory and cultural services and establishes cross-organizational rights, responsibilities, and openness rules through resource orchestration and ecosystem collaboration, pointing toward think-tank and social service value. The two chains share data governance as a common foundation and are mutually dependent-the open service chain relies on the data assets and methods produced by the knowledge production chain, while external demands in turn provide new research questions for the knowledge production chain.

The third layer is value creation: the knowledge production chain yields knowledge production value, the open service chain yields think-tank and social service value, and talent cultivation is a spillover of both. The three public value constraints (accessibility, accountability, and fairness) act simultaneously on the processes and outcomes of both chains, keeping the framework from remaining stuck in an efficiency logic.

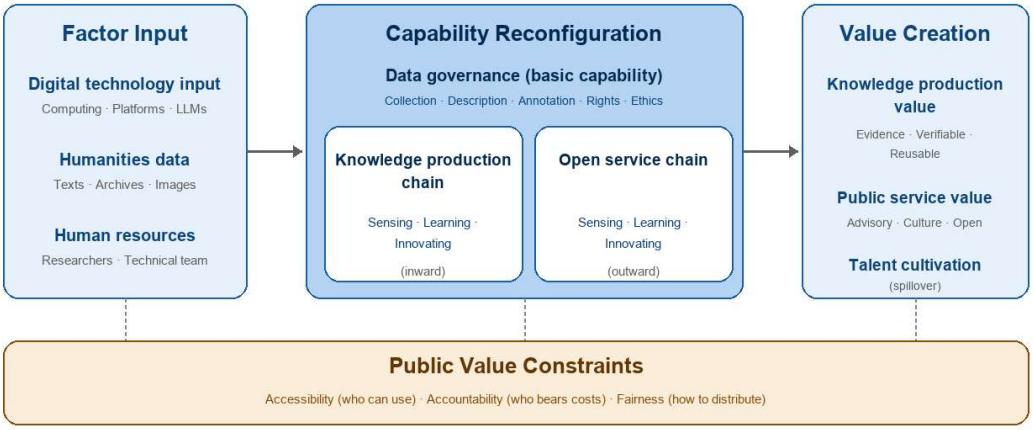


Figure 1. Factor Input–Capability Reconfiguration–Value Creation Analytical Framework

3. Capability Reconfiguration: The Mechanism of Value Transformation from Digital Technology Investment

3.1. Data Governance: The Foundation of Capability Reconfiguration

The research objects of liberal arts laboratories-archives, interview records, field notes, and images of cultural artifacts-are mostly unstructured data and belong to individual researchers. Existing research notes that the construction of university liberal arts laboratories is shifting from traditional equipment management toward a governance model centered on data assets, yet management and operation still face problems such as data fragmentation, a lack of quality standards, and insufficient privacy protection [9]. To address this problem, it is necessary to transform scattered personal materials into computable and reusable data assets at the organizational level-that is, data governance, encompassing collection, description, annotation, rights confirmation, and ethical review. Some laboratories, through long-term accumulation, have formed data assets such as thesauri, knowledge graphs, and high-resolution image databases, which is precisely the manifestation of effective governance.

Data governance is the common foundation of the two functioning chains because it determines the starting point of all subsequent links. For the knowledge production chain, humanities data can be processed by computational methods only after standardized description and annotation; untreated raw materials cannot directly enter the computational process. For the open service chain, only data that have undergone rights confirmation and ethical review can be opened and shared beyond the university; otherwise data openness instead brings compliance risks. Under the conditions of unstructured and scattered humanities data, the absence of data governance means that digital technology investment can at most produce scattered outputs by individual researchers, making it difficult to form accumulative and reusable laboratory data assets or to support external openness and sharing.

3.2. The Mechanism of Knowledge Production

Computational methods do not automatically generate research questions. The problem consciousness of humanities research originates from disciplinary traditions-computational methods acquire meaning for knowledge production only when they are translated into tools for solving specific disciplinary questions. The knowledge production capability of liberal arts laboratories is first manifested in the judgment of which questions within a discipline are suitable for computational treatment-large-scale textual criticism in historical research, corpus statistical analysis in linguistic research, and stylistic measurement in literary research are all the results of establishing correspondences between disciplinary questions and computational methods. Jiang (2023), based on an analysis of 26 computational social science laboratories in universities worldwide, found that context-driven design, innovation networks, knowledge clusters, and evaluation accountability constitute the overall framework of liberal arts knowledge production in the digital age, performing the functions of goal orientation, computing support, digital collaboration, and quality control respectively [10]. Well-functioning laboratories typically have humanities scholars raise research questions and computational staff provide methodological support, forming mixed teams in a question-driven manner so that methods serve specific questions; laboratories lacking this link fall into the predicament of "platforms built but equipment idle."

Once questions are established, whether knowledge production can be sustained depends on whether humanities scholars can gradually master and apply these methods during the research process. Researchers and computational staff refine their collaboration through joint research, methods are constantly adjusted along with questions, and scholars acquire skills such as data processing and text analysis in the course of collaboration-skills that then settle into reusable research capabilities for the laboratory rather than one-off services dependent on particular technical staff. Only when scholars can independently raise computational questions and preliminarily judge the applicability boundaries of methods does digital technology truly become a routine tool for knowledge production.

When computational methods are truly embedded in the research process, what changes is not merely the research tool but the way of posing questions and the standards of evidence: historical research moves from case-based textual criticism to quantitative analysis of large-scale texts, and the verifiability and reusability of research conclusions improve accordingly. Whether digital technology investment can be transformed into knowledge production value ultimately depends on whether this step is completed.

3.3. The Mechanism of Open Service

The public service of liberal arts laboratories is oriented beyond the discipline-policy advisory, digitization of cultural heritage, and data openness-and whether it can create value depends first on whether the laboratory can identify and respond to these demands. Policy research requires large-scale public opinion and literature analysis, cultural heritage protection requires the digitization of artifacts, and regional development requires thematic data support-all of which are real demands that the laboratory's data and computational capabilities can respond to. Without sensing these demands, the laboratory's open service becomes disconnected from the outside world, and its data assets remain deposited internally rather than being transformed into something usable by society.

After sensing demand, whether collaboration can be sustained depends on whether the laboratory can progressively codify rights and responsibilities, benefit distribution, and the scope of openness into written rules. External collaboration by liberal arts laboratories often begins with external requirements such as applications and evaluations; institutional pressure can initiate collaboration but does not necessarily sustain it. Only when the collaborating parties gradually clarify rights and obligations, benefit attribution, and openness boundaries, and sediment these consensuses into reusable institutional arrangements, can collaboration transcend individual transactions and become a stable service capability of the laboratory.

4. Value Creation and Public Value Constraints

4.1. Two Forms of Value Creation

The outcomes of capability reconfiguration are ultimately embodied in the value created by the laboratory, which takes two forms. The first is knowledge production value, that is, the gains of digital transformation to academic research itself: machine-readable large-scale texts, archives, and images shift research from sampling to full coverage; the reproducibility and traceability of computational processes move humanities research from "a single voice" to verifiable results; and standardized data assets can be directly invoked by subsequent research, reducing duplicated labor. The second is public service value, that is, the laboratory's contribution to society beyond the discipline-supporting policy advisory with data and computational capabilities, participating in the protection and dissemination of cultural heritage through digital means, and lowering the threshold for others to access knowledge and data through open sharing.

These two forms of value are not isolated. Knowledge production value is the foundation of public service value-without solid academic output, social service becomes water without a source; public service value in turn provides new questions and resources for knowledge production, as the real demands emerging from policy advisory and cultural services can be transformed into new research questions. Talent cultivation is a spillover of both-students acquire digital literacy and interdisciplinary training through participating in data governance and computational research-and the educational value of research-oriented laboratories depends on the former two rather than being an independent goal.

4.2. Public Value Constraints: Accessibility, Accountability, and Fairness

The value judgment of liberal arts laboratories cannot stop at "how much is produced." Yang (2024) points out that traditional evaluation of liberal arts research is oriented primarily toward the "individual," whereas liberal arts laboratories rely on team building to produce shared academic outcomes, which traditional evaluation cannot accommodate [11]. As an academic organization funded by public money, its value must be judged by "for whom value is created, who legitimates it, and who bears the costs"-this is precisely the significance of public value constraints. This paper operationalizes this constraint into three tests. Accessibility answers "who can use": to whom equipment, data, and outcomes are opened, and whether the threshold for use is lowered as much as possible on the premise of protecting sensitive information. Accountability answers "who bears costs and risks": who is responsible for data rights confirmation and ethical review, and who is accountable for the biases and misjudgments that large models and algorithms may introduce. Fairness answers "how resources, recognition, and benefits are distributed": whether authorship, funding, and reputation in interdisciplinary collaboration are fair, and whether disadvantaged disciplines, minority languages, and marginalized texts are brought into view.

These three constraints are not "remedial measures" after value creation but the preconditions for whether value can be continuously created. Existing evaluation often applies science and engineering standards, dominated by efficiency indicators such as equipment utilization and output quantity; this mismatch in turn shapes laboratory behavior-evaluation that only measures efficiency induces laboratories to tighten data and equipment openness, weaken accountability, and squeeze fairness, thereby weakening value creation itself. Evaluation indicators are not a measurement of existing value but an institutional force that changes value-creating behavior-which is why public value constraints must run through the entire transformation rather than being retrofitted afterward.

5. Implementation Paths: Strategies for Advancing Digital Transformation

5.1. Data Resourceification: Consolidating the Foundation of Digital Transformation

The starting point of digital transformation lies in transforming the unstructured humanities materials accumulated over time by liberal arts laboratories into computable and reusable data assets. This requires laboratories to change the status quo of "building separate databases and holding them in a scattered manner," establish unified data standards and description norms, collect, annotate, and catalog raw materials such as texts, archives, and images, and simultaneously establish data rights confirmation and ethical review mechanisms to clarify the attribution and usage boundaries of data. It should be emphasized that the effectiveness of data governance should not be measured by the number of databases built but by the degree of standardization, reusability, and external citation of data assets-only data that can be reused constitute the true foundation of transformation.

5.2. Method Integration: Seizing the Core of Digital Transformation

The core of digital transformation lies not in equipment renewal but in whether computational methods can be integrated into the process of humanities research. To this end, laboratories should establish a joint "question–method" topic-selection mechanism in which humanities scholars raise research questions and computational staff provide methodological support, advancing research through mixed teams; they should also establish dedicated positions and authorship rules for computational staff so that joint humanities-computation outcomes are recognized. Only when humanities scholars gradually master computational methods through collaboration and methods settle into reusable research capabilities of the laboratory can digital technology investment be truly transformed into knowledge production value.

5.3. Open Collaboration: Expanding the Boundaries of Digital Transformation

The value of digital transformation is not confined within the discipline but should extend to social services. Laboratories should proactively expand external collaboration in response to real demands such as policy advisory, cultural heritage digitization, and data openness; at the same time, to prevent collaboration from fluctuating with evaluation cycles, rights and responsibilities, benefit distribution, and the scope of openness should be codified into written rules so that cooperation can operate sustainably under institutional safeguards. In this way, the laboratory's data and computational capabilities can be transformed into public service value, and the value boundaries of transformation can be expanded.

5.4. Evaluation Reform: Providing Institutional Support for Digital Transformation

Whether digital transformation can be continuously advanced ultimately depends on the adaptation of the evaluation system. Existing evaluation is dominated by efficiency indicators such as equipment utilization and output quantity, which contradicts the value logic of liberal arts laboratories and may inversely induce laboratories to tighten openness and weaken accountability. To this end, accessibility, accountability, and fairness should be incorporated into laboratory assessment, and transformation outcomes should be measured by liberal-arts-adapted indicators such as the external reuse of datasets, the breadth of open sharing, and the duration of collaborative projects. The essence of evaluation reform is to provide an institutional environment commensurate with digital transformation.

6. Conclusion

This paper focuses on the digital transformation of university liberal arts laboratories and constructs an analytical framework of "factor input–capability reconfiguration–value creation." It argues that the essence of digital transformation in liberal arts laboratories is capability reconfiguration rather than equipment renewal: digital technology investment can be transformed into knowledge production value and public service value only through data governance and the two functioning chains, both of which unfold along the three links of sensing, learning, and innovating, while public value constraints constitute the institutional conditions for the sustained creation of value. The analysis in this paper remains primarily theoretical, its propositions await empirical testing, and its observation of the internal decision-making processes of laboratories is still insufficient. Future research can examine the differences in capability reconfiguration paths of liberal arts laboratories across disciplinary attributes and governance contexts through multi-case comparison, and further identify the respective boundaries of data governance, method integration, and open collaboration in value transformation through qualitative comparative analysis or necessary condition analysis.

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 and the Laboratory Work Branch Project of Zhejiang Society of Higher Education "Research on the Open Sharing and Coordinated Innovation Model of Laboratories in the Context of New Liberal Arts" fund.

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