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From card catalogs to chatbots: envisioning academic library services in the era of AI and LLMs

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Abstract

Purpose – This article introduces the CARDLG framework: Collections, Access, Retrieval, Description, Literacy and Governance. The framework analyzes how generative artificial intelligence (AI) and large language models reconfigure recurring library infrastructural dimensions rather than representing wholly unprecedented disruption.

Design/methodology/approach – The analysis draws on library history from manuscript repositories through digital discovery systems, tracing how each CARDLG dimension evolved across technological eras. It identifies continuities, accelerations and ruptures in AI/large language model (LLM) implementations compared to prior infrastructural shifts such as card catalogs, online public access catalogs and web-based discovery layers.

Findings – AI/LLMs extend familiar challenges including vendor dependence and opaque retrieval algorithms while introducing distinct risks tied to synthetic answer generation, training data governance and output accountability. The framework reveals how AI integration cuts across all six dimensions simultaneously, requiring coordinated decision-making across collections, systems, instruction and governance units.

Originality/value – This article provides a historically informed analytical framework for library practitioners navigating AI adoption. It offers CARDLG-based design principles, implementation scenarios across discovery, metadata, literacy instruction and vendor negotiation contexts, and stakeholder implications across library roles. The framework enables deliberate, values-aligned decisions rather than reactive adoption driven by vendor timelines.

Keywords Academic libraries, Large language models, Information infrastructure, Library history, AI governance, Library services

Paper type Research article

1. Introduction: from card catalogs to chatbots

Generative artificial intelligence (AI) and large language models (LLMs) have rapidly diffused across academic libraries since late 2022, prompting experiments with chat-based discovery, AI instruction and automated metadata work (Chowdhury and Chowdhury, 2024; Khan *et al.*, 2024). Many practitioners view AI/LLMs as radically new, demanding unprecedented frameworks and competencies. Yet treating AI/LLMs as wholly discontinuous risks overlooking longer infrastructural trajectories.

Academic libraries have repeatedly reconfigured core functions: from manuscript repositories to card catalog systems, from Online Public Access Catalogs (OPACs) to web-based discovery layers, and from print-only collections to data-intensive research support. Each shift changed how libraries stored, described and mediated information. AI/LLMs intensify some familiar dynamics, such as vendor dependence, opaque algorithms and shifting user expectations, while introducing new forms of risk tied to synthetic answer generation, training data governance and output accountability.

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Recent scholarship has produced valuable accounts of generative AI in academic libraries. Studies examine opportunities and challenges across service areas such as information retrieval and access (Boateng, 2025; Chowdhury and Chowdhury, 2024), apply normative frameworks to interrogate algorithmic bias, data privacy and epistemic injustice in AI-enabled library environments (Matsieli and Mutula, 2025), and propose conceptual and adoption frameworks for integrating AI into library services (Jan *et al.*, 2024; Okunlaya *et al.*, 2022). This body of work documents an ongoing transition with care and increasing sophistication. What it does not yet provide is a systematic framework for situating AI/LLMs within the longer infrastructural history of library transitions. Existing literature addresses AI as a discrete event requiring practical response, ethical evaluation or adoption readiness assessment, rather than as a new configuration of infrastructural dimensions that have shaped library work across every major technological era. Without such a framework, libraries risk treating well-understood challenges as unprecedented and overlooking accumulated institutional expertise in vendor negotiation, algorithmic opacity and shifting user expectations. They also risk the inverse error, treating genuinely new dynamics such as synthetic answer generation, training data governance and output accountability as merely continuous with what came before.

This article addresses that gap by introducing the CARDLG framework: Collections, Access, Retrieval, Description, Literacy and Governance. It makes three contributions. First, it offers a historically grounded analytical framework that organizes library infrastructural work into six recurring dimensions and traces their evolution from manuscript repositories through AI-enabled discovery systems. Second, it applies this lens to distinguish continuities, accelerations and ruptures across all six dimensions in the current AI/LLM era, revealing where libraries can draw on existing expertise and where new frameworks are essential. Third, it translates this analysis into design principles, illustrative implementation scenarios and stakeholder implications intended to support deliberate, values-aligned decision-making for practitioners across library roles.

This article treats the academic library as an information reservoir, a bounded store of content, data and tools, embedded within a mediating system, the socio-technical arrangements through which users, knowledge and institutional goals interact. This infrastructure-first view foregrounds continuities that can be obscured by novelty. CARDLG organizes this analysis into six dimensions. Section 2 defines each dimension in detail. AI is not outside this framework but rather a new configuration of CARDLG.

Two aims guide the discussion. First, it offers a historical narrative of academic library infrastructures framed by CARDLG, from bounded manuscript collections through web discovery and data-intensive practice. Second, it uses this lens to analyze how AI/LLMs reconfigure CARDLG and to articulate design principles and strategic questions for contemporary practice. The intended audience includes academic and research library professionals across roles and library and information science scholars interested in infrastructural change and technology governance.

The approach is conceptual and synthetic. It does not provide technical evaluations of specific AI tools, prescriptive organizational redesigns or comprehensive cost models. The focus is on academic and research libraries, with brief points of comparison to other contexts. The goal is a useable framework for thinking through AI/LLM-era services and policies in light of longer infrastructural trajectories, clarifying where challenges are familiar and where they represent genuine rupture.

2. Conceptual frame: libraries, CARDLG and cross-cutting patterns

2.1 Libraries as information reservoirs

The concept of "information reservoir" has formal origins in stochastic thermodynamics, where Deffner and Jarzynski (2013) define it as a precisely bounded subsystem that exchanges

information but not energy, characterized by both what it retains and what it releases. Library scholarship has adopted the term, but primarily as a descriptive label: health sciences libraries are characterized as information reservoirs essential to institutional research, education and patient care missions (Love, 1986); parliamentary libraries are described as operating as information reservoirs alongside information management systems (Rugambwa, 2010); and university libraries are broadly designated as information reservoirs serving teaching, learning and research (Ganaie, 2016; Moruf, 2020). In each instance, the term names where information is held without theorizing the structure of that holding: what determines the reservoir's boundaries, what is included or excluded and under what conditions contents are released to users.

This article extends the reservoir concept in a direction more analytically consistent with its formal definition. An information reservoir is a bounded store of content, data and increasingly tools, shaped by institutional, legal and technical constraints. Like its thermodynamic counterpart, the library reservoir is defined not only by what it contains but by the conditions governing exchange: budgets, licensing terms, physical and technical capacity, and policy choices determine what enters the reservoir, what is excluded and under what conditions access is permitted. Those boundaries are dynamic rather than fixed. Open access policies, data-sharing mandates and AI tool integrations all aim to open the reservoir, but each opening introduces new constraints, including platform dependence, revised licensing and expanded data governance obligations, that reconstitute the boundary rather than dissolve it. This bounded, curated character persists across all technological eras, from manuscript repositories to AI-enabled discovery systems.

This reservoir concept is related to but distinct from three adjacent bodies of scholarship. Repository models, exemplified by Lynch's (2003) foundational account of institutional repositories as organizational commitments to the stewardship, preservation and dissemination of digital scholarly materials, address the bounded and curated dimensions but center on scholarly output as the primary unit of analysis. Scholarly output represents only a subset of what the full library reservoir holds. Information infrastructure scholarship draws on Star and Ruhleder's framework of infrastructure as a social and technical construct that is embedded in organizational practices, built upon an installed base and visible primarily upon breakdown (Borgman, 2000), a perspective recently extended to libraries by Kusuma (2026). These accounts foreground the system-level arrangements surrounding the reservoir, including governance mechanisms, socio-technical standards and institutional interdependencies, but give less analytic attention to the bounded, curated character of the store itself. Socio-technical network models such as Rosenbaum and Joung's (2004) STIN framework illuminate the heterogeneous actors through which digital libraries operate, including people, technologies, resources and legal arrangements, capturing the mediating layer while leaving the reservoir's boundary structure undertheorized. The information reservoir concept proposed here holds both dimensions simultaneously: what is bounded and curated, and the socio-technical arrangements through which it is organized and made accessible. The latter constitute the mediating system examined in §2.2.

2.2 Libraries as mediating systems

Libraries are also mediating systems: people, technologies, workflows and policies that shape how users encounter information (Chang, 2013). Mediation is not neutral facilitation. Cataloging decisions privilege certain forms of description and authority; search interfaces embed assumptions about relevance and user intent; instruction programs convey particular epistemic norms. Recognizing libraries as mediating systems foregrounds the infrastructural work that operates beneath the surface of "simple" interactions like searching a catalog or asking a reference question. These mediating choices shape not only what users find but how they understand the nature and limits of library services.

2.3 The CARDLG model

The CARDLG model organizes library infrastructural work into six dimensions:

C: Collections. Content, data and tools stewarded by the library, including print and digital publications, datasets, code, licensed platforms, discovery systems and AI models. Collection development decisions determine what enters the reservoir and what is prioritized.

A: Access. Authentication, licensing and policy arrangements that determine who can use which resources, under which conditions and from where. This includes technical infrastructure such as proxy services and single sign-on systems, legal agreements such as licenses and data use agreements, and policy decisions such as open access mandates and tiered access for sensitive data.

R: Retrieval. Interfaces and interaction logics through which users search for, navigate and obtain resources, including card catalogs, OPACs, databases, discovery layers, APIs and conversational chatbot interfaces. Retrieval systems embed assumptions about user intent and about what counts as a satisfactory result.

D: Description. Cataloging, metadata creation and the standards and infrastructures that make resources legible to humans and machines, including controlled vocabularies, classification schemes, authority files and the labor of creating, maintaining and migrating metadata.

L: Literacy. Instructional and consultative work that helps users reason critically with information systems and sources, including information literacy, data literacy and related forms of user support.

G: Governance. Intellectual property, ethical, policy and risk frameworks that structure decisions across the other five dimensions, including copyright and fair use, privacy and retention policies, vendor contracts and institutional commitments to equity, intellectual freedom and transparency.

2.4 Cross-cutting patterns

Three patterns cut across CARDLG dimensions and will surface throughout this analysis. First, roles and labor evolve with each infrastructural shift. Professional identities and expertise change from custodians and catalogers to reference librarians, systems librarians, data librarians and now emerging AI coordinators. Second, user behavior and expectations shift. Users move from expecting highly mediated, in-person assistance to self-service search and now to expectations of instant, synthesized answers. Third, spaces and materiality reconfigure from physical reading rooms to learning commons to primarily virtual platforms. These patterns interact with CARDLG but are not reducible to any single dimension.

2.5 Developing the CARDLG framework

Approaches to analyzing library infrastructure have generally taken one of two forms. Technology adoption frameworks, including the Technology-Organization-Environment model applied extensively in library settings (Jan *et al.*, 2024) and acceptance frameworks such as the Unified Theory of Acceptance and Use of Technology, examine the organizational, technological and environmental factors that shape libraries' decisions to adopt specific technologies. Service frameworks such as Schonfeld's (2018) nine-area portfolio typology organize library functions in terms of user-facing outcomes, from facilitating information access to fostering scholarship and convening campus communities. Both approaches offer genuine analytical value, but both are oriented toward a single point in time, analyzing a particular technology or a particular service configuration rather than examining how library infrastructure reconfigures across technological eras. Neither is well suited to revealing what persists, what intensifies and what genuinely ruptures as libraries move from one infrastructural era to the next.

Buckland's functional analyses of library service come closest to the approach taken here. His examination of library services as a system identifies recurring functional dimensions

including inquiry, retrieval, becoming informed, demand and resource allocation (Buckland, 1988), and his typology of Paper, Automated and Electronic Libraries traces how the technology of documents and operations has reconfigured across eras while the underlying purpose of providing access to information persists (Buckland, 1992). Carr's (2014) application of the Social Construction of Technology framework to Ranganathan's Five Laws similarly identifies enduring principles underlying library practice, arguing that libraries are technologies whose meaning is continuously shaped by user communities. These functional and principled analyses establish important precedents. They do not, however, systematically account for description, literacy and governance as recurring infrastructural dimensions alongside collections, access and retrieval, nor do they extend beyond the electronic library era to the conditions that characterize AI-enabled services.

Infrastructure scholarship provides the theoretical orientation from which CARDLG proceeds. Borgman (2007) establishes that scholarly information infrastructure is deeply embedded in technology, policy and social arrangements. Mattern (2014) proposes that libraries are best understood as networks of mutually reinforcing infrastructures, architectural, technological, social, epistemological and ethical, that evolve together across time. These accounts situate libraries within broader systems of knowledge production and governance but provide less analytical traction on the specific recurring dimensions within which library infrastructural work takes place. The historical analysis in Sections 3 through 5 traces how libraries have navigated recurring challenges across every major infrastructural transition, from manuscript repositories to AI-enabled discovery systems and that analysis reveals six dimensions present in every era even as their implementations change: the content, data and tools libraries steward; the licensing and policy arrangements determining who can use which resources under which conditions; the interfaces and interaction logics through which users find and obtain them; the descriptive and metadata work that makes resources legible; the instructional and consultative work that helps users reason critically with information systems and sources; and the ethical, legal and policy frameworks governing decisions across all five. The framework designates these dimensions Collections, Access, Retrieval, Description, Literacy and Governance. Unlike adoption frameworks, CARDLG examines each not as a discrete implementation challenge but as a recurring infrastructural site where continuities and ruptures can be identified across eras. Sections 3 through 5 trace this recurring structure across library history, establishing the analytical foundation for examining AI/LLMs in Section 6.

3. Before automation: bounded libraries and closed reservoirs

3.1 Elite archives and ecclesiastical libraries, ancient to medieval

Ancient and medieval libraries typically functioned as closed reservoirs, though with significant variation across regions and institutions. Collections consisted primarily of rare manuscripts, such as religious texts, legal codes and select philosophical works, which were curated by rulers and ecclesiastical authorities (Setton, 1960). Access was generally restricted to rulers, clergy and select scholars, usually requiring physical presence, though some institutions developed lending systems for authorized users.

Retrieval depended heavily on staff with tacit knowledge. While formal public search systems were rare, some libraries maintained inventories that organized materials by subject matter or author, foreshadowing the standardized access points (author, title, subject) that would become central to card catalog systems. Description took various forms, from simple shelf lists to more elaborate author or subject arrangements. Medieval librarians experimented with organizational schemes by grouping texts by discipline, creating author indices, which anticipated the controlled vocabularies and classification systems formalized centuries later, though shared standards across institutions had not yet emerged (Guthrie, 1992).

Literacy instruction had not yet developed as a specialized library function; learning occurred through apprenticeship in theological or administrative training. Governance was often explicit and restrictive: ecclesiastical and state authorities determined which texts could

circulate and who could access them through censorship and canons of permitted knowledge. Knowledge remained scarce, controlled and mediated primarily through interpersonal relationships.

3.2 Early modern and print-era scholarly libraries, early print to 19th century

The spread of printing expanded collections dramatically, though at different rates across Europe and beyond. Libraries accumulated printed books, journals, pamphlets and government documents. Collections grew in volume and variety, constrained by acquisition budgets and physical storage but also shaped by emerging debates about what constituted valuable knowledge. Libraries increasingly became sites of scholarship, supporting emerging scientific societies and universities (Merisalo *et al.*, 2023).

Access and retrieval broadened unevenly. Reading rooms expanded access in some institutions, though status, location and institutional affiliation continued to limit entry. Printed catalogs enabled more systematic finding, building on manuscript-era organizational experiments and introducing new possibilities for alphabetical arrangement and cross-referencing. Renaissance bibliographers like Conrad Gessner proposed comprehensive subject classification systems that, while not fully implemented, articulated organizational principles that would guide later development of standardized systems (Fischer, 1966). Retrieval still typically required staff mediation for complex queries, but the intellectual framework for independent user navigation was emerging.

Description and Literacy matured together as cataloging practices began to standardize, though with considerable local variation. Libraries developed increasingly sophisticated subject headings and classification schemes; users learned to navigate these evolving organizational structures through informal guidance and practice. Governance gradually expanded from primarily censorship-focused control toward emerging copyright frameworks and circulation policies, foreshadowing the complex intellectual property and access negotiations that would characterize the digital era.

4. Print and early automation: card catalogs, standardization and early computing

4.1 The card catalog as retrieval infrastructure

The card catalog system represented a major retrieval innovation. Retrieval became structured through standardized access points: author, title and subject. Users could search independently for straightforward queries. The catalog embodied information seeking based on discrete bibliographic records and controlled vocabularies.

Description became increasingly standardized. Cataloging codes like Anglo-American Cataloguing Rules (AACR) and Machine-Readable Cataloging (MARC) established shared practices. Controlled vocabularies like Library of Congress Subject Headings and classification systems supported consistent description across institutions (Mangan, 2007).

Collections expanded in scale and in diversity of formats, but the reservoir remained primarily print. Access continued to be governed through physical presence and institutional membership, though interlibrary loan expanded sharing across reservoirs. Literacy began to formalize through bibliographic instruction as users confronted the complexity of catalogs, indexes and reference sources (Mangan, 2007). Governance included copyright and circulation policy, but also the governance of standards, decisions about which classification systems and subject headings to adopt.

4.2 Early automation and the transition to machine-readable systems

Computing began to shape library infrastructures through back-end automation: circulation systems, acquisition workflows and cataloging utilities. These developments reconfigured labor, shifting routine tasks from manual to machine-assisted processes. Machine-readable catalogs enabled bibliographic data to be shared and reused. Union catalogs and shared

cataloging networks emerged, reducing duplicated labor and increasing standardization. Description became more scalable but more dependent on external infrastructure. Libraries relied on shared utilities for catalog records.

Retrieval remained anchored in physical card catalogs, though digital foundations were laid. Access remained primarily physical. Collections expanded but remained print-centric. Literacy emphasized catalog navigation. Governance expanded to include automation investments and standards adoption. This era demonstrates a common pattern in infrastructural transition: automation often begins in back-end operations, such as circulation systems, acquisitions and cataloging workflows, which reshapes library labor before users encounter new interfaces.

5. Online, web and data-intensive eras: digital expansion and platform dependence

5.1 Online catalogs and web discovery, 1970–2010s

OPACs transformed retrieval through keyword searching and remote access, changing user expectations toward speed and convenience. Users appreciated search flexibility but struggled with controlled vocabularies (Bowman, 2007; Salony, 1995). Web-based discovery layers later promised unified searching but introduced opaque vendor-controlled ranking algorithms (Dahl, 2009).

Collections expanded from early electronic resources (CD-ROMs, online indexes) to massive, licensed journal packages. Access shifted from simple authentication to complex licensing, proxy systems and open access initiatives as counterforces to vendor dependence. Description faced scale challenges as metadata aggregated from multiple sources with varying quality. Literacy instruction pivoted from teaching search mechanics toward critical evaluation of web sources and database results (ALA, 2015).

Governance grew increasingly complex. Libraries negotiated intricate vendor contracts that shaped access in ways often opaque to users. Copyright, privacy and intellectual freedom concerns intensified. New roles emerged: systems librarians, e-resources specialists and web UX designers.

5.2 Data-intensive research support, 2000–2020s

Collections broadened beyond publications to datasets, software and institutional repositories. Access involved data sharing policies, embargo management and permissions for sensitive data. Libraries navigated open data mandates while managing privacy and intellectual property restrictions (Walton, 2010).

Retrieval systems integrated publications and data through repository platforms and APIs. Description expanded to rich metadata for datasets using DOIs and evolving standards (Witt, 2008). Literacy broadened dramatically as data literacy and research data management (RDM) became core services, including FAIR principles and systematic review support (Yu, 2017). Data librarians and RDM specialists became standard in research libraries, though institutional variation was substantial: research universities tend to build dedicated services while smaller institutions embed support within liaison roles.

5.3 Setting the stage for AI/LLMs

Across digital eras, CARDLG reveals clear patterns. Collections expanded beyond local print to licensed packages and diverse data types (Walton, 2010; Witt, 2008). Access grew complex through authentication infrastructures and license negotiations (Chakraborty *et al.*, 2024). Retrieval became apparently simple through single search boxes while growing opaque through hidden algorithms (Dahl, 2009). Description intensified in complexity while becoming less visible to users (Mangan, 2007). Literacy pivoted from search mechanics to critical evaluation and data practices (ALA, 2015; Salony, 1995). Governance shifted from local policies to intricate vendor contracts and platform dependencies (Bowman, 2007).

User expectations rose steadily: from "I must ask a librarian" to "I expect instant, comprehensive results." These patterns set the stage for understanding AI/LLMs not as entirely novel but as intensification of existing trajectories.

6. The AI/LLM era through the CARDLG lens

This section applies the CARDLG framework to analyze how AI/LLMs reconfigure each of the six dimensions. The analysis traces what is familiar (continuities), what intensifies (accelerations) and what is genuinely new (ruptures). Taken together, these analyses inform the design principles developed in §7.

6.1 Collections: content, corpora and models

AI/LLMs blur traditional collection boundaries in two distinct ways. First, AI is being integrated into collection development workflows: predictive analytics tools can analyze circulation patterns, identify underutilized materials and forecast resource demand, offering new forms of evidence-based acquisition and weeding (Dhara, 2025; Omeluzor and Ojukwu, 2024). These uses extend familiar collection management goals through new technical means.

The more structurally novel challenge is treating AI tools as collection items in their own right. Libraries now decide whether to license vendor-hosted AI platforms, deploy local models, or curate corpora for RAG systems (Buitrago-Ciro *et al.*, 2025; Tai and Ghosh, 2025), and these decisions carry costs and licensing complexities that differ substantially from traditional content acquisitions (Chakraborty *et al.*, 2024). AI platforms are computational artifacts trained on massive corpora that may not overlap with library holdings. A chatbot trained on open web data includes unlicensed content outside institutional control; a RAG system constrained to the institutional repository makes the library's curated corpus the epistemic boundary of what the system can generate (Bevara *et al.*, 2025). In each configuration, collection decisions shape what knowledge the system can surface and what it cannot. Libraries must evaluate AI platforms not only by features and costs but by training data, coverage and embedded assumptions, criteria for which traditional collection evaluation frameworks provide limited guidance.

6.2 Access: licensing, data flows and institutional constraints

AI licensing differs from traditional content subscriptions. Models may use per-seat pricing, per-token fees or enterprise agreements with unclear cost trajectories (Chakraborty *et al.*, 2024). Access negotiations must address user prompts, logs and uploaded documents: are inputs used to retrain models, how long are they retained and who owns outputs? These questions are not merely contractual but technical: personal data submitted through AI interfaces is transformed into model parameters in ways that make regulatory rights such as the right to erasure technically difficult to enforce even when institutions intend to comply (Feretzakis *et al.*, 2025). Policies must clarify acceptable use under General Data Protection Regulation (GDPR) and applicable student privacy laws, but compliance is further complicated by evidence that formal consent mechanisms may not satisfy regulatory requirements when power relationships between users and institutions are unequal (Bai *et al.*, 2024; Katulic and Katulic, 2025).

Data flows raise governance concerns beyond the immediate user interaction. Users may inadvertently share sensitive research with vendors, and AI systems are increasingly acting as users themselves: crawlers harvest digital library collections and institutional repositories to train models without explicit consent, creating accessibility disruptions and copyright concerns that fall outside existing licensing frameworks (Barba *et al.*, 2026). Access varies by institutional resources and national data sovereignty regulations, and librarians navigating these responsibilities encounter gaps in specific regulatory knowledge, lack of uniform standards across institutions and difficulty verifying what vendor data practices actually entail

(Olusipe *et al.*, 2024). Libraries must consider equity implications: does AI access deepen inequities in who can leverage research tools, and whose institutional collections become training material without compensation or consent?

6.3 Retrieval: conversational search and synthetic answers

AI/LLMs transform retrieval from returning item lists to generating synthetic prose, representing a paradigm shift from traditional search systems toward interactive dialogue with intelligent agents (Alaofi *et al.*, 2025; Schneider *et al.*, 2023). Users provide natural language prompts; systems interpret intent, search data and synthesize results. This increases accessibility but introduces opacity.

Relevance criteria disappear from view. Traditional systems returned distinct items users could evaluate independently. AI/LLMs may return synthesized text drawing from multiple sources, paraphrasing them or generating plausible but factually ungrounded content: LLMs may produce linguistically consistent but inaccurate outputs through probabilistic methods trained on potentially stale or biased data, and the lack of standardized evaluation metrics makes detecting such errors difficult even for system designers (Rahman *et al.*, 2026). Users cannot easily verify claims, trace reasoning or assess completeness.

User mental models compound these challenges. Users could over-trust confident AI outputs and may be significantly more likely to adopt AI-generated narratives than opposing information from established sources, with the interactive agency of conversational interfaces enhancing perceived credibility beyond what accuracy warrants (Ding *et al.*, 2025; Govers *et al.*, 2025). AI opaqueness further complicates calibration: users would find it harder to predict system behavior, backtrack errors or understand how outputs were produced, even when the fluent surface of the interaction suggests otherwise (Bach *et al.*, 2024). What appears as collaborative information seeking is in fact a fundamentally asymmetric interaction: the system has no mutual understanding of user goals, no reciprocal adaptation to evolving needs and no stake in whether retrieved information is accurate (Shah and Tamine, 2026). AI literacy must therefore teach users to interrogate the system itself, recognizing that confident-sounding answers may be synthesized from uncertain information and that underlying processes remain opaque even to experts.

6.4 Description: AI-assisted metadata

AI/LLMs can suggest subject headings, generate summaries, extract entities and support authority control across cataloging workflows (Engel *et al.*, 2025; Reshi *et al.*, 2026). Catalogers face labor-intensive backlogs and inadequate staffing for growing digital collections, making AI assistance appealing (Chen and Li, 2024). However, automated metadata annotation is only as good as the training data available for a given domain: scholarly and historical content is frequently unavailable in the volumes and formats machine learning requires, limiting performance precisely where library collections are most specialized and culturally distinctive (Wu *et al.*, 2023).

Risks extend beyond data availability. AI-generated description reproduces training data biases, potentially applying inappropriate terms, misrepresenting cultural context or flattening identities. Controlled vocabularies have long embedded bias in library organizing systems, a problem documented across decades of professional critique of subject heading schemes (Knowlton, 2005), but AI introduces new amplification pathways at scale (Dai *et al.*, 2024). Crucially, AI-assisted classification is not a neutral technical operation but an epistemological act of organizing knowledge in accordance with particular worldviews encoded in training data (Reshi *et al.*, 2026). Managing this bias requires active, ongoing human engagement and institutional accountability rather than claims of algorithmic objectivity, since bias is an unavoidable consequence of any situated organizing system and must be made visible and correctable (Coleman, 2020).

Plausible-looking outputs hide errors. Accountability remains unclear: who is responsible when AI generates harmful subject headings, and how are records corrected and systems

audited? Libraries must determine whether AI assistance augments description work safely or undermines professional commitments to careful, culturally responsive cataloging.

6.5 Literacy: AI literacy and the future of information literacy

AI/LLMs intensify literacy needs across multiple dimensions. Users rely on chatbots for search, writing, summarization and reasoning, and effective engagement requires not only technical familiarity but also critical thinking, ethical reasoning, social awareness and understanding of legal implications (Hackl *et al.*, 2026). Instruction shifts from teaching search mechanics to teaching calibration: when to trust, when to verify and how to interpret probabilistic outputs.

AI literacy intersects with and challenges existing information literacy frameworks. The ACRL Framework emphasizes authority as constructed and research as inquiry (ALA, 2015), and each of its frames can be applied to generative AI: the authority frame applies to evaluating whether AI outputs carry genuine epistemic standing within a research context, and the information creation frame applies to understanding how AI generates text through probabilistic processes rather than human judgment (James and Filgo, 2023). However, AI/LLMs strain these frames by producing text that mimics authoritative sources without revealing provenance, training data or the processes underlying output generation. Instruction must address model limitations, hallucinations, training data biases and the ethics of AI use in academic work. This requires a shift from evaluating individual sources to interrogating the system itself: understanding how outputs are generated, recognizing that confidence of expression does not indicate factual accuracy and knowing that underlying processes remain opaque even to experts.

Staff also need training on how AI/LLMs work, their risks and communication strategies for working with users. Even in academic communities with significant prior technological literacy, acceptance and use of AI tools varies widely and depends on institutional support, perceived usefulness and prior experience (Strzelecki *et al.*, 2024). Literacy encompasses both user instruction and the organizational learning required to embed that instruction in consistent, values-aligned practice (ACRL, 2025).

6.6 Governance: ethics, policy and platform power

AI/LLM governance encompasses privacy, intellectual property, equity and accountability, but these concerns are interconnected in ways that existing governance frameworks have only partially addressed. Existing AI governance frameworks, though numerous, tend to be fragmented, sector-specific and difficult to translate from abstract principles into consistent operational practice, particularly in organizations that lack centralized control over platform decisions (Robles and Mallinson, 2025). Prompt logs and user interactions raise privacy concerns as vendors collect and retain data across sessions, creating obligations that libraries must evaluate under applicable regulatory frameworks such as GDPR and student privacy law (Katulic and Katulic, 2025). Libraries must determine what data flows are acceptable, under what conditions and how these obligations cascade to vendor contract negotiations.

The intellectual property landscape is especially unsettled. Most AI systems are trained on datasets whose provenance, licensing status and consent mechanisms are poorly documented, creating substantial legal exposure for institutions that deploy or endorse these tools. Fair use questions arise when AI outputs echo copyrighted materials, but existing legal precedents have struggled to address these cases consistently (Maryala, 2025). Equity and intellectual freedom are equally central: AI models reproduce and amplify biases embedded in their training data, shaping what knowledge surfaces and whose knowledge counts (Dai *et al.*, 2024). Governance must address model evaluation, bias auditing and transparency, yet the mechanisms for doing so in library contexts remain largely underdeveloped.

Platform power compounds these challenges. Many AI/LLMs are controlled by large technology firms whose decisions about training data, algorithmic behavior and pricing

structures occur at scales and speeds that libraries, as individual institutions, cannot match or monitor (Meimandi *et al.*, 2025). Translating responsible AI principles into operational accountability is difficult even for large multinational organizations with dedicated governance infrastructure; for libraries with constrained resources and limited negotiating leverage, the gap between principle and practice is wider still (Meimandi *et al.*, 2025). Institutional AI governance frameworks across higher education reveal how policy ambiguity tends to individualize failure, placing compliance burdens on frontline librarians, instructors and users rather than addressing structural accountability at the platform level (Li *et al.*, 2026; Tsao, 2025). Libraries risk repeating earlier patterns of publisher dependence at greater scale and with less transparency into vendor behavior.

Strategic decisions facing libraries include whether to license vendor AI tools, build local capacity, participate in consortial open-model initiatives or defer adoption pending more stable governance conditions. The CARDLG framework reveals why these decisions cannot be made through governance alone: choices about vendor contracts and acceptable data flows shape what content enters and remains in the collection, who can access it under what conditions, how retrieval is mediated, what descriptions are generated and what users can be taught about system trustworthiness. Governance is not one dimension among six but the framework within which all other CARDLG decisions carry ethical and institutional weight.

6.7 Continuities and ruptures across CARDLG dimensions

Understanding AI/LLMs requires distinguishing what is familiar from what is genuinely new. Treating AI/LLMs as wholly unprecedented can lead to reactive adoption and underuse of institutional experience with vendor dependence, opaque algorithms and shifting user expectations. But overemphasizing continuity risks complacency. AI/LLMs introduce new epistemic dynamics: synthetic answer generation, training data governance and risks that outpace traditional governance mechanisms. Table 1 maps these continuities, accelerations and ruptures across all six CARDLG dimensions.

AI/LLMs simultaneously continue, accelerate and rupture existing CARDLG patterns. Understanding which dynamics are familiar helps libraries apply accumulated expertise: vendor negotiation strategies, user education methods, governance policies and professional values. Recognizing genuine ruptures prevents complacency and highlights where new frameworks, policies and practices are essential. The CARDLG lens reveals that treating AI/LLMs as "just another technology" is as misguided as treating them as wholly unprecedented.

7. Design principles for AI/LLM integration

The CARDLG analysis translates into actionable principles for practitioners. Technology adoption scholarship consistently shows that implementation decisions focused narrowly on cost-benefit analysis and functional requirements tend to produce adoption-implementation gaps, where technologies are acquired but not effectively integrated into organizational practice (Rogers, 2003). In library settings, the Technology-Organization-Environment model and related acceptance frameworks reveal that successful technology integration depends on organizational readiness, workflow fit and policy infrastructure alongside technical capability, not technical features alone (Abeysekera *et al.*, 2024; Jan *et al.*, 2024). The principles below apply this insight across CARDLG dimensions: rather than treating each adoption decision as isolated, they prompt libraries to examine how choices cascade across all six dimensions and to ground AI integration in institutional values rather than vendor timelines or novelty pressure. These principles are not step-by-step instructions but frameworks for asking the right questions when making decisions about AI integration across collections, access, retrieval, description, literacy and governance.

Table 1. CARDLG in the AI/LLM era: continuities, accelerations and ruptures

CARDLG dimension	Continuities (what persists)	Accelerations (what intensifies)	Ruptures (what Breaks from prior patterns)
Collections (C)	Libraries already collect tools alongside content (databases, discovery systems)	AI platforms compete with content budgets; tool collection becomes more central and expensive	Models contain hidden corpora libraries cannot audit; traditional collection ethics (known content) no longer apply
Access (A)	Licensing and authentication are familiar infrastructural concerns	Usage-based pricing and vendor lock-in intensify; access inequities may widen	User inputs/outputs (prompts, uploads) become data assets requiring governance – queries are now "content"
Retrieval (R)	Opaque ranking algorithms not new (discovery layers, vendor indexes)	Conversational interfaces intensify opacity; users see single answers not item lists	Retrieval becomes generative – systems produce new text rather than pointing to existing resources
Description (D)	Metadata work has always involved human judgment and embedded biases	AI can scale description work, reducing backlogs and increasing coverage	Probabilistic outputs are nondeterministic; same input yields different results, undermining systematic error correction
Literacy (L)	Critical evaluation of sources and systems has long been central to IL	AI increases volume of plausible misinformation; users rely on summaries over sources	Users must evaluate system trustworthiness, not just source credibility – requires understanding training data, uncertainty, bias
Governance (G)	Libraries have always navigated copyright, privacy, vendor negotiations	Platform power asymmetry intensifies; vendors are now technology giants with misaligned values	Platform decisions about training data and algorithmic behavior occur at scales/speeds libraries cannot control; governance becomes reactive
Cross-cutting tensions	Libraries balance openness, innovation and stability	Pressure to adopt tools users expect conflicts with deliberative risk assessment	Proprietary closed systems conflict with library values of openness; innovation speed outpaces governance capacity

Source(s): Author's own work

7.1 CARDLG-based principles and strategic questions

Collection strategy must treat AI platforms as major acquisitions, not add-on tools. Decisions about licensing vendor-hosted models, deploying local systems or curating corpora for retrieval-augmented generation carry the same strategic weight as major content investments. Libraries should ask: How do AI tools fit within collection priorities alongside content subscriptions, open access support and data curation? What local corpora, including institutional repositories, digital collections and licensed databases, should or should not connect to AI/LLM-powered systems? How can libraries evaluate the "collection value" of an AI platform: not just its features, but the training data, coverage and biases it embodies?

Access decisions require long-term caution and equity analysis. AI licensing models differ from traditional subscriptions, often involving per-seat pricing, per-token usage fees or enterprise agreements. Libraries should assess: What are the cost structures and how sustainable are they over multi-year horizons? What data flows are involved, specifically who retains logs of user prompts, uploads and outputs, and under what terms? How do different licensing models affect equity, potentially privileging certain user groups, departments or research areas over others?

Retrieval infrastructure should maintain transparency behind conversational interfaces wherever possible. While AI/LLMs offer accessible natural language interaction, libraries must clearly communicate system limitations. Key questions include: For which tasks is

AI-mediated discovery appropriate, such as exploratory browsing and brainstorming, and for which is it inappropriate, such as systematic reviews and authoritative answers? How will users see the evidence underlying synthesized answers: can systems link back to source documents, provide confidence scores or flag uncertainties? What fallback mechanisms exist when AI retrieval fails or produces hallucinations?

Description work should use AI to augment, not replace, expert judgment, with clear accountability. AI-assisted metadata can address backlogs but must align with established standards and professional commitments. Libraries should determine which descriptive tasks are low-risk candidates for AI assistance, such as initial subject suggestions for review and clustering similar items, and which require full human judgment, such as complex special collections and culturally sensitive materials. What oversight, audit and correction workflows will ensure quality? How can libraries document when AI has been used in metadata creation and what review occurred?

Literacy programs must integrate critical AI literacy into existing frameworks. As users increasingly rely on AI/LLMs for search, writing and reasoning, instruction shifts from teaching search mechanics to teaching calibration and critical evaluation. Libraries should scaffold understanding by asking: How can instruction help students and faculty understand AI/LLMs not as magic answer boxes but as probabilistic systems trained on specific corpora with specific limitations? What discipline-specific guidance do different fields need, such as AI for literature review in STEM versus writing support in humanities? How can libraries address academic integrity concerns while acknowledging legitimate exploratory uses of AI/LLMs?

Governance must make AI decisions visible, deliberative and grounded in core library values. Privacy, equity, intellectual freedom and transparency should guide AI adoption. Critical governance questions include: How are policies about AI tool adoption developed, and who is involved, including librarians, faculty, students, IT and legal counsel? What frameworks exist for evaluating AI tools against library values? How can libraries measure and report impacts on equity, privacy and intellectual freedom, ensuring adoption serves rather than undermines institutional commitments?

7.2 Cross-cutting consideration: roles and labor

Research on technology integration in academic environments confirms that adoption challenges are organizational as much as technical: staff attitudes, training availability and institutional support structures shape whether new tools are effectively embedded in practice across roles (Strzelecki *et al.*, 2024). Building distributed AI competency rather than concentrating expertise in isolated positions reflects what diffusion research identifies as a condition for sustainable institutionalization: knowledge must spread through normal professional channels rather than remaining at the organizational periphery (Rogers, 2003).

AI integration cuts across traditional library roles, requiring coordinated competency development. Rather than creating isolated "AI librarian" positions, libraries should build distributed expertise while clarifying coordination mechanisms. Strategic questions about roles and labor include: What training do different staff groups need, such as subject librarians advising on discipline-specific AI use, instruction coordinators developing AI literacy curricula, metadata professionals evaluating AI-assisted workflows and systems administrators managing technical integration? Should AI-related responsibilities be distributed across existing roles or concentrated in dedicated positions? How can libraries avoid overburdening early adopters while ensuring knowledge spreads across the organization? What coordination structures, such as working groups, communities of practice and administrative oversight, can align efforts across collections, systems, instruction and governance units? Investment in staff capacity is investment in deliberative, values-aligned AI integration. Without distributed understanding, libraries risk reactive adoption driven by vendor pressure rather than institutional priorities.

8. Illustrative scenarios for AI in academic libraries

This article presents four scenarios showing how CARDLG applies to specific implementations. Each includes narrative context, key decisions, required resources, potential pitfalls and CARDLG dimensions involved.

8.1 Scenario 1: chat-enhanced discovery interface

Narrative. A library implements a chatbot interface layered over its discovery system, constrained to search vetted sources, licensed databases, institutional repository and selected OA collections. Users ask questions in natural language; the system retrieves relevant items and generates brief summaries with source links (Fruehauf *et al.*, 2026; Michalak *et al.*, 2025).

Decisions. What content is in scope? How are sources presented, ranked list, synthesized summary, both? What happens when the system cannot answer or produces a hallucination? How are corrections communicated to users?

Resources. Staff time for system configuration, testing and monitoring. Training for reference staff who field questions about the system. Vendor or local technical support for integration.

Pitfalls. Users may over-trust synthesized summaries and skip examining sources. Ambiguity about system scope may lead users to expect comprehensive answers the system cannot provide. Unanticipated biases in summarization may misrepresent sources.

CARDLG. C, defining content scope, R, conversational interface design, L, teaching users how to interpret and verify results, G, policies on acceptable use, data logging and error correction.

8.2 Scenario 2: AI-assisted metadata for theses and dissertations

Narrative. The library uses an AI/LLM to generate summaries and suggest subject headings for electronic theses and dissertations (ETDs), with human review before records are finalized (Chow *et al.*, 2024; Morgan, 2025).

Decisions. What level of human review is required, spot-checking, full review? How is AI involvement documented in catalog records? What thresholds trigger revision or rejection of AI-generated metadata?

Resources. Cataloging staff time for oversight. Technical infrastructure to integrate AI tools into cataloging workflow. Ongoing evaluation of metadata quality.

Pitfalls. Subtle misclassification may go unnoticed in spot-checking. Loss of local subject nuance if AI-generated headings are accepted uncritically. Staffing constraints may lead to reduced oversight over time.

CARDLG. D, metadata creation practices, C, how ETDs are made discoverable, G, internal policies on automation and quality standards.

8.3 Scenario 3: AI literacy workshops and consultation

Narrative. Librarians develop workshops and consultation services on using AI/LLMs ethically and effectively for research and writing. The program includes guidance on prompt strategies, verification, citation practices and academic integrity (Ali and Richardson, 2025).

Decisions. What stance is taken on AI use: permissive, restrictive, discipline-specific? How is guidance coordinated with faculty and writing centers? How are workshops tailored for different user groups, undergraduates, graduate students, faculty?

Resources. Staff time to develop curriculum and teaching materials. Professional development to build internal expertise. Partnerships with faculty, writing centers and IT.

Pitfalls. Workshops may be framed as tool training rather than critical literacy. Rapid tool changes may outpace curriculum updates. Conflicting campus policies may confuse users.

CARDLG. L, instructional content and pedagogy, G, alignment with institutional policy and academic integrity norms, R, understanding retrieval and answer generation behavior to teach verification.

8.4 Scenario 4: negotiating an AI vendor contract

Narrative. A library considers licensing an AI-enhanced discovery platform. The vendor offers an integrated chatbot interface across licensed content. The contract includes terms about usage logs and potential model improvement (Gupta, 2026; Michalak *et al.*, 2025).

Decisions. What data rights are acceptable? Can the vendor use prompts to train models? What retention period is allowed? What transparency is required about retrieval scope and model behavior? How are costs structured?

Resources. Legal counsel, procurement expertise and staff time for negotiation. Technical review of platform capabilities. Governance committee input to assess alignment with institutional values.

Pitfalls. Contracts may be opaque, with vague language about data use. Power asymmetry may limit negotiation outcomes. Pressures to adopt quickly may lead to insufficient review.

CARDLG. A, access and licensing terms, G, governance and policy alignment, R, understanding retrieval scope and transparency, C, assessing the platform as part of collection strategy.

9. Implications for practice and research

AI/LLM integration requires coordinated action from practitioners across roles and sustained scholarly inquiry into implementation outcomes, user behavior and governance models. This section outlines stakeholder implications and identifies research directions that can advance both practice and scholarship.

9.1 Stakeholder implications across library roles

CARDLG applies across library functions, offering a shared vocabulary for aligning stakeholders with different priorities and expertise. Collection development and systems staff face interconnected decisions about AI tool acquisition and integration. Traditional evaluation criteria, such as coverage, cost and relevance, must expand to include model training corpora, data governance, platform dependencies and infrastructure requirements. Collection staff negotiate contracts resembling software licensing; systems staff manage technical integration (authentication, APIs, data flows), monitoring, error handling and security. AI tools raise new security and privacy concerns: user prompts may be retained by vendors, uploaded documents may be used to train models and integrations with library systems may create vulnerabilities requiring coordination between systems staff, legal counsel and information security teams.

Cataloging and metadata professionals will face pressures to adopt AI-assisted workflows to address backlogs and improve discoverability. They must design oversight and audit processes, advocate for standards alignment and manage bias risks. Documentation of AI involvement in metadata may become a professional norm, requiring new workflows for tracking automated contributions and human review.

Instruction and public services librarians must integrate AI literacy into existing programs and field user questions about AI tools, trust, citation and ethics. They will also confront shifts in user expectations: users may arrive with AI-generated answers seeking verification, or they may expect libraries to provide AI tools directly. Balancing critical evaluation with practical guidance requires coordination with faculty and writing centers to ensure consistent campus messaging.

Users and institutional risk stakeholders experience AI from different vantage points. Users experience AI tools as both convenience and risk, with AI/LLM interfaces reducing barriers to discovery and writing support but potentially misleading through hallucinations and overconfident outputs. Disciplinary adoption patterns vary widely, creating campus policy inconsistencies. Meanwhile, institutional stakeholders such as legal counsel, compliance officers and IT security focus on privacy, intellectual property and regulatory compliance, including GDPR, FERPA and data protection laws. AI adoption may raise questions around

contract terms, data governance and institutional liability. Libraries must coordinate closely across these units to ensure AI tools align with institutional risk frameworks.

Library administrators and team leads coordinate cross-unit decision-making, budgeting and policy development. AI adoption cuts across collections, systems, instruction and governance, requiring integrated planning. Administrators face strategic questions about whether to invest in local capacity, participate in consortial AI initiatives or rely on vendor tools. They must balance innovation pressures with risk management and ensure AI decisions reflect institutional values rather than vendor-driven timelines. CARDLG provides a shared framework that helps surface questions often overlooked, clarify what's gained and lost in different approaches and ensure coordinated decision-making across collections, systems, instruction and governance units.

9.2 Research directions

Scholarly inquiry can address critical knowledge gaps while supporting evidence-based practice. Urgent empirical priorities include user behavior in AI-mediated discovery: how users interact with synthesized answers, calibrate trust and adjust search strategies when AI tools are available. Organizational impact studies should examine how libraries adjust roles, workflows and staffing when adopting AI tools. Comparative case studies across institutional types, such as R1 universities, liberal arts colleges and community colleges, as well as national contexts, can assess how resources, governance structures and cultural factors shape AI integration.

Design and implementation research can build practical knowledge. Prototyping transparent AI-augmented discovery interfaces can test designs that surface sources, provide confidence scores and flag uncertainties. Co-designing AI-supported metadata workflows with catalogers can identify which tasks benefit from automation and which require human judgment. Evaluating instructional interventions for AI literacy can build evidence on effective pedagogies for teaching calibration, verification and ethical use across disciplines.

Critical and interdisciplinary work addresses deeper questions. What counts as evidence, authority and interpretation in AI systems versus library epistemologies? How do power, labor and platformization reshape AI-mediated infrastructures? How do equity and access concerns manifest in contexts of uneven AI availability? Interdisciplinary collaborations with researchers in human–computer interaction, science and technology studies, communication, computer science and education can advance both scholarship and practice. Libraries serve as research sites where AI is deployed and as research partners contributing expertise in information systems, metadata and user support. Together, practitioner engagement and scholarly inquiry can ensure AI integration serves library values rather than undermining them.

10. Conclusion: limitations and future directions

10.1 Scope and limitations

This article offers a conceptual synthesis rather than empirical evaluation. The historical narrative draws on existing scholarship but does not present new archival or ethnographic research. The focus on academic and research libraries limits direct applicability to public, school or special libraries, though many principles may transfer. The scenarios are illustrative, not exhaustive. Readers in specific contexts will need to adapt CARDLG to local conditions, institutional priorities and available resources.

10.2 Core contributions and next steps

CARDLG separates familiar challenges, including vendor dependence and opaque retrieval, from distinct risks tied to synthetic answer generation, training data governance and output accountability that require genuinely new frameworks and policies. In practice, the framework

supports clearer trade-offs across adoption decisions, more consistent terminology across library roles and more explicit alignment between AI integration choices and institutional values.

Next steps include empirical evaluation of AI/LLM-mediated discovery and instruction in real library settings and collaborative development of governance templates that address privacy, equity, transparency and accountability across CARDLG dimensions.

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