Anusandhanvallari
Vol 2024, No.1
December 2024
ISSN 2229-3388

"Artificial Intelligence in Digital Libraries: Enhancing User Experience, Information Retrieval, and Service Delivery"

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Abstract: Artificial intelligence (AI) is rapidly changing the architecture of digital libraries by shifting user interaction from conventional keyword-based retrieval toward conversational search, recommendation, automated metadata enrichment, semantic discovery, and adaptive service delivery. This paper examines how these changes affect user experience (UX), with particular attention to usefulness, usability, trust, accessibility, personalization, information quality, privacy, and human oversight. A structured evidence review was conducted using 30 authenticated scholarly and institutional sources spanning foundational digital-library evaluation research and contemporary AI-in-library studies. Evidence was synthesized from empirical surveys, mixed-method studies, systematic and scoping reviews, user-evaluation research, human-AI interaction scholarship, and international governance frameworks. Results indicate that AI can improve discovery, responsiveness, personalization, and service availability, but these gains are conditional rather than automatic. Published evidence shows strong interest in AI-enabled services, alongside persistent concerns about insufficient training, opaque algorithms, uneven collection coverage, privacy disclosure, bias, and the reliability of generated answers. In an environmental scan of 31 academic-library chatbots, 94% were AI-powered or hybrid, 42% supported multiple languages, but only 13% disclosed privacy policies. A North American survey of 242 librarians found that 67% expected AI-related technologies to transform library functions and 68% expressed interest in training. A recent systematic review found that funding was cited as a major institutional challenge in 48.28% of the 29 included studies. Across the evidence base, the most consistent UX determinants were relevance, ease of use, system functionality, transparency, information quality, and the availability of human escalation.

Keywords: artificial intelligence; digital libraries; user experience; academic libraries; chatbots; recommender systems; information retrieval; human-AI interaction; AI ethics; library services

1. Introduction

Digital libraries have evolved from collections of digitized objects into complex service environments that combine content, metadata, discovery tools, authentication systems, institutional repositories, research support, learning services, and increasingly intelligent interfaces. Early digital-library scholarship emphasized that a digital library should not be understood merely as a database or technical platform; it is simultaneously an information system and an institutional service built for identifiable user communities [1]. This dual character remains important because the success of a digital library depends not only on the quantity of accessible content but also on whether users can discover, understand, trust, and effectively use that content.

User experience therefore occupies a central place in digital-library quality. Long before contemporary generative AI, digital-library evaluation scholars argued that assessment must go beyond system speed or retrieval metrics and include contextual, behavioral, service, and user-centered dimensions [2,3]. Empirical research subsequently demonstrated that perceived usefulness and perceived ease of use are major determinants of digital-library acceptance, while terminology clarity, screen design, navigation, accessibility, relevance, and user differences can shape adoption [4,5]. User-centered studies similarly showed that usability and collection quality are consistently valued, alongside service quality, system performance, and mechanisms for incorporating user opinion [6-10]. These foundations matter because AI does not replace traditional UX requirements; rather, it adds new layers of interaction and risk to them.

The current wave of AI in libraries includes machine-learning recommendation, natural-language processing, semantic retrieval, automated classification, conversational agents, large language models (LLMs), generative summarization, and data-driven decision support. Interviews with library leaders anticipated AI effects on search and discovery, scholarly communication, learning support, infrastructure, data curation, and information literacy [11]. Surveys of librarians have since documented growing awareness and use, but also substantial demand for training and uncertainty about what counts as AI in library practice [12,13]. Ethical research has further emphasized that information professionals face questions involving privacy, autonomy, bias, explainability, social justice, intellectual freedom, data ownership, and professional responsibility [14,15]. Generative AI intensifies these issues because fluent outputs can obscure uncertainty and may present fabricated, incomplete, biased, or decontextualized information with unwarranted confidence [16].

The relevance of AI to UX is therefore more profound than adding a chatbot to a library website. AI changes how queries are formulated, how results are ranked, how recommendations are produced, how users interpret system authority, and how much personal data may be captured to personalize services. Contemporary research shows a shift from speculative discussion toward implementation studies and systematic evidence. Scoping and systematic reviews have identified reference and information services, technical processing, circulation, collection development, information literacy, professional development, recommendation, and automated indexing as major application areas [17-21]. Recent empirical work on academic-library chatbots and public-library AI services confirms that performance expectancy, AI literacy, social influence, semantic interpretation, privacy disclosure, and service integration can influence uptake and satisfaction [22,23]. Mixed-method work in 2026 also suggests that users treat security, ethics, and information quality as baseline requirements rather than optional enhancements [24], while research on algorithm aversion indicates that poor relevance, inadequate platform functionality, and weak collection coverage can trigger resistance even when an AI system is technically sophisticated [25].

Human-AI interaction research provides an additional conceptual bridge. General guidelines for AI-infused interfaces emphasize setting appropriate expectations, explaining system capabilities, supporting correction, enabling efficient dismissal, learning from user behavior cautiously, and maintaining user control [26]. At the same time, scholarship on large language models warns that scale and fluency do not eliminate problems of bias, representational harm, opacity, environmental cost, and misleading linguistic performance [27]. International governance frameworks reinforce requirements for transparency, fairness, privacy, accountability, human oversight, and risk management [28,29]. For libraries—institutions that mediate access to knowledge and often operate under public-interest values—these principles are directly relevant to UX design.

This paper examines the relationship between AI, digital libraries, and user experience through a structured synthesis of authenticated evidence. The objectives are to: (i) identify the main AI applications currently shaping digital-library interaction; (ii) analyze documented effects on usability, usefulness, personalization, trust, accessibility, and service quality; (iii) summarize quantitative findings from representative studies without fabricating new primary data; (iv) identify risks and implementation barriers; and (v) propose a user-centered framework for responsible AI integration in digital libraries. The central argument is that AI improves library UX only when it strengthens the core functions that users already value—relevance, clarity, access, efficiency, and confidence—while preserving transparency, privacy, inclusion, and meaningful human support.

2. Literature Review

Digital-library UX as the foundation

Digital-library UX research established several principles that remain valid in the AI era. Saracevic described digital-library evaluation as a multidimensional problem involving what is evaluated, in what context, for what purpose, and according to which criteria [2]. Marchionini similarly argued for longitudinal and multifaceted evaluation because the value of digital libraries emerges through continuing interaction among content, technology, users, and tasks [3]. These perspectives resist a narrow definition of UX based solely on interface attractiveness or click efficiency.

Technology-acceptance research added empirical support. Thong, Hong, and Tam examined 397 digital-library users and found that perceived usefulness and perceived ease of use strongly influence acceptance [4]. Hong and colleagues likewise connected system characteristics and individual differences to adoption [5]. User-centered evaluation studies found that users give high priority to usability and collection quality, while also considering service quality, performance, and opportunities to express opinions [6]. Fuhr and collaborators proposed a flexible evaluation framework for digital libraries, recognizing that no single metric captures system success [7]. Xie's later research demonstrated that actual user judgments reflect task context, preferences, knowledge structure, and perceived evaluation criteria [8]. Subsequent work expanded evaluation dimensions and measures, including information organization, interface design, system and technology, effects on users, user engagement, administration, and context [9,10].

From automation to intelligent and generative library services

The "intelligent library" literature anticipated a broad transformation of discovery and professional work. Cox, Pinfield, and Rutter's interviews with 33 thought leaders identified likely effects on search and resource discovery, scholarly publishing, learning, data curation, infrastructure, and information literacy [11]. Their work also highlighted data quality, intelligibility, ethics, and the danger that libraries could become peripheral to vendor-driven AI development. This concern remains significant because many discovery platforms and generative services are externally controlled, limiting institutional visibility into training data, ranking logic, and product updates.

Librarian surveys demonstrate that adoption is shaped by organizational readiness as well as technical capability. Hervieux and Wheatley received 163 responses from academic librarians in Canada and the United States; their findings showed interest in AI but also uncertainty about definitions, applications, and training needs [12]. Yoon, Andrews, and Ward surveyed 242 North American public and academic librarians and found that 67% believed AI and related technologies would transform library functions, while 68% were interested in training [13]. These results suggest that staff competence is itself a UX factor: users cannot receive consistent guidance when librarians lack confidence in how an AI service works, what data it uses, or when its output should be questioned.

Professional roles are also changing. Cox argues that AI may shift academic-library work toward hybrid competencies combining domain knowledge, data literacy, critical evaluation, vendor management, and human-centered service design [15]. The ethical dimension is equally important. His eight-scenario analysis illustrates how AI adoption can raise conflicts around surveillance, bias, automation, accountability, and social justice that cannot be resolved by generic professional codes alone [14]. Libraries therefore require operational governance processes that connect technical deployment with service values.

Generative AI, personalization, and conversational reference

The emergence of ChatGPT and comparable systems accelerated interest in conversational discovery and generative reference services. Lund and Wang identified potential benefits in reference, search, metadata generation, and content production while warning about privacy and bias [16]. Subsequent reviews have moved beyond speculation. Danquah and colleagues' scoping review mapped a large body of global literature and proposed implementation strategies for academic libraries, emphasizing readiness, capacity building, policy, and context [17]. Ngulube and Mosha focused specifically on "safe" integration, underscoring risk assessment and responsible institutional design [18].

Evidence from India adds a user perspective. Haris and colleagues analyzed 383 academic-library users and found that demographic variables such as gender and age did not produce significant differences in overall perceptions, while education level influenced AI knowledge [19]. This is important because it suggests that AI literacy may not simply follow age stereotypes; targeted education should be based on observed competencies and tasks rather than assumptions about particular groups.

Systematic reviews published in 2026 show that implementation remains uneven. Ayinde, Ebiefung, and Oladokun synthesized 29 studies from 2020-2024 and categorized AI practice across technical services, reference and information services, administration and circulation, collection development, information literacy and user education, and professional development [20]. They reported that funding was cited as a major institutional challenge in 48.28% of the included articles. Neamatollahi and Danesh's systematic review of AI-driven personalization selected 24 studies from an initial pool of 460 and concluded that NLP, recommendation systems, and machine learning were prominent techniques, with reported benefits for service quality and user satisfaction but recurring concerns about privacy, bias, transparency, and limited real-world deployment [21].

Chatbot research provides a concrete test of UX claims. Liu and Liu evaluated 31 academic-library chatbots and found that 94% were AI-powered or hybrid, 42% provided multilingual support, and only 13% disclosed privacy policies [22]. Most systems handled basic service queries more reliably than complex, metadata-rich, context-sensitive tasks. This gap illustrates a central UX challenge: conversational fluency can make users expect broad competence even when a system is optimized primarily for FAQs or narrow retrieval tasks. In public libraries, Kang found that AI literacy, facilitating conditions, social influence, performance expectancy, and effort expectancy influenced intention to use AI chatbot services [23]. These findings align closely with classic digital-library acceptance research [4,5], suggesting continuity in user behavior despite major technological change.

Trust, algorithm aversion, and responsible design

Recent work reframes trust as an interaction outcome rather than a general attitude toward AI. Fan and Hu's mixed-method study of generative-AI knowledge services identified security, ethics, and information quality as "must-be" needs, while discovery capabilities and service architecture functioned as performance drivers [24]. Cao and colleagues' mixed-method research on algorithm aversion found that relevance, accuracy, complexity, platform functionality, resource coverage, and update speed were central to resistance; privacy and bias concerns sometimes became salient after dissatisfaction had already occurred [25]. This suggests that trust cannot be improved through an ethics statement alone. Users first encounter trust through whether the system works, whether the collection is adequate, and whether failures are recoverable.

Human-AI interaction principles offer practical design guidance. Amershi and colleagues developed 18 guidelines validated by 49 design practitioners across 20 AI-infused products, stressing expectation management, contextual relevance, feedback, correction, and user control [26]. For digital libraries, these principles translate into clear labeling of AI-generated content, visible source links, explanations of why items are recommended, options to reformulate or revert to conventional search, and mechanisms for escalating to a librarian.

Anusandhanvallari
Vol 2024, No.1
December 2024
ISSN 2229-3388

The risks of generative language models also require critical attention. Bender and colleagues show that large language models can reproduce social biases, obscure training-data limitations, and create misleading impressions of understanding [27]. UNESCO's global AI ethics recommendation places human rights, dignity, transparency, fairness, privacy, accountability, and human oversight at the center of responsible AI governance [28]. NIST's AI Risk Management Framework similarly emphasizes governance, mapping, measurement, and management of AI risks throughout the system life cycle [29]. Applied to digital libraries, these frameworks support a UX model in which trustworthiness is designed, documented, tested, and continuously monitored rather than assumed from vendor claims.

3. Materials and Methods

This study used a structured evidence-review design to synthesize scholarship at the intersection of artificial intelligence, digital libraries, and user experience. The approach was selected because the field contains heterogeneous evidence: foundational conceptual work, usability and acceptance studies, librarian and user surveys, scoping and systematic reviews, environmental scans of deployed tools, mixed-method studies, and normative governance frameworks. A statistical meta-analysis would therefore be inappropriate because constructs, populations, outcomes, and study designs are not sufficiently homogeneous.

The review followed transparency principles associated with systematic evidence synthesis and PRISMA 2020 reporting guidance, particularly in defining eligibility, documenting source selection, and distinguishing published findings from the present authors' synthesis [30]. It is not represented as an exhaustive database-wide PRISMA systematic review; instead, it is a focused, reproducible structured review of 30 authenticated sources selected to cover both the historical foundations of digital-library UX and the contemporary AI evidence base.

Search scope and eligibility

The evidence window extended from 1999 to September 2026. Searches focused on combinations of the concepts "artificial intelligence," "generative artificial intelligence," "digital library," "academic library," "public library," "user experience," "usability," "user acceptance," "chatbot," "recommendation," "personalization," "algorithm aversion," "information retrieval," "AI ethics," and "human-AI interaction." Publisher pages, DOI records, institutional repositories, recognized indexing records, and official institutional publications were used to authenticate bibliographic details and reported findings.

Sources were included when they met at least one of four criteria: (1) foundational peer-reviewed research defining or evaluating digital-library UX; (2) empirical or review research on AI adoption or service delivery in libraries; (3) human-AI interaction research directly relevant to user-facing AI systems; or (4) authoritative governance frameworks relevant to responsible AI deployment. Studies were excluded if bibliographic provenance could not be verified, if they consisted only of promotional commentary, or if numerical claims could not be traced to a scholarly or institutional source.

4. Results

Overview of the evidence

The 30-source corpus shows a clear transition in the literature. Earlier work concentrated on digital-library definitions, acceptance, usability, evaluation criteria, and multidimensional measures [1-10]. Research from 2019 onward increasingly addresses intelligent discovery, professional readiness, ethics, generative AI, personalization, chatbots, and algorithmic trust [11-29]. The shift is not a replacement of one research tradition by another; rather, the AI literature repeatedly returns to established UX variables such as perceived usefulness, ease of use, relevance, system quality, and service support.

Table 1 summarizes representative empirical and review studies that contribute directly to the present synthesis. The evidence spans expert interviews, librarian surveys, user surveys, scoping and systematic reviews, chatbot evaluations, and mixed-method studies. Sample sizes and corpus sizes vary substantially, reinforcing the decision not to pool outcomes statistically.

Table 1. Representative authenticated studies relevant to AI-enabled digital-library UX

Study	Design	Sample/corpus	Focus	Key evidence relevant to UX
Cox et al., 2019 [11]	Expert interviews	33 thought leaders	Search/discovery, publishing, learning, data and infrastructure	AI expected to alter discovery and professional roles; concerns included data quality, ethics and intelligibility.
Hervieux & Wheatley, 2021 [12]	Survey	163 academic librarians	AI perceptions and virtual assistants	Interest in AI coexisted with definitional uncertainty and a need for more training.
Yoon et al., 2022 [13]	Survey	242 public/academic librarians	Adoption of AI-related technologies	67% expected transformation of library functions; 68% were interested in training.
Haris et al., 2025 [19]	User survey	383 academic-library users	Perception and adoption in India	Education influenced AI knowledge; no significant overall perception differences by gender or age.
Danquah et al., 2024 [17]	Scoping review	478 relevant records analyzed	Global AI implementation evidence	Implementation requires context-sensitive strategy, infrastructure, capacity and policy.
Ayinde et al., 2026 [20]	Systematic review	29 studies	Academic-library AI practices/challenges	Reference/information services were prominent; 48.28% of included articles cited funding as a major challenge.
Neamatollahi & Danesh, 2026 [21]	Systematic review	24 included studies	AI personalization	NLP, recommendation and ML were prominent;

				benefits accompanied by privacy, bias and transparency concerns.
Liu & Liu, 2026 [22]	Environmental scan + review	31 academic-library chatbots	Reference chatbots	94% AI/hybrid; 42% multilingual; 13% disclosed privacy policies; complex retrieval quality varied.
Kang, 2026 [23]	Survey/regression	Public-library users	AI chatbot acceptance	AI literacy, social influence, facilitating conditions, performance and effort expectancy affected intention to use.
Cao et al., 2026 [25]	Mixed methods	41 user interviews + DEMATEL	Algorithm aversion in academic digital libraries	Relevance, accuracy, system functionality and collection conditions were central drivers of resistance.

Table 1. Representative authenticated evidence used in the synthesis.

Quantitative signals from the contemporary evidence

Several published numerical findings illustrate both momentum and immaturity in AI-enabled library services. Yoon and colleagues reported that 67% of 242 surveyed librarians expected AI-related technologies to transform library functions and 68% were interested in training [13]. In the 2026 academic-library chatbot scan, 94% of the 31 systems were AI-powered or hybrid and 42% supported multiple languages, but only 13% disclosed privacy policies [22]. Ayinde and colleagues found that funding was identified as a major institutional challenge in 48.28% of the 29 studies included in their systematic review [20]. These percentages arise from different designs and should not be statistically compared; together, however, they demonstrate a recurring pattern of high technological interest coupled with governance and capacity gaps.

Scale and heterogeneity of the evidence base

The evidence base is heterogeneous in scale. Expert-interview work may involve several dozen strategically selected participants, while surveys include hundreds of librarians or users and scoping reviews analyze hundreds of records. Figure 2 displays reported sample or corpus sizes from selected studies [11-13,17,19,21,22,25]. Larger samples do not automatically imply stronger causal evidence; the figure instead demonstrates the range of methodologies informing current knowledge.

Across these methods, four findings recur. First, AI-related services are most credible to users when retrieval relevance and system functionality are strong [21,22,25]. Second, user acceptance is influenced by classic technology-acceptance variables such as performance expectancy, effort, usefulness, facilitating conditions, and literacy [4,5,23]. Third, organizational capacity including funding, staff skills, policy, infrastructure, and vendor management affects what users ultimately experience [13,17,18,20]. Fourth, responsible UX increasingly requires visible privacy, transparency, source provenance, and human oversight [14,21,22,28,29].

Table 2. UX dimensions for evaluating AI-enabled digital libraries

UX dimension	AI mechanism	Potential benefit	Primary risk	Suggested measures
Usefulness/task success	Semantic retrieval, query reformulation, conversational guidance	Faster path to relevant evidence	Hallucination, shallow answers, wrong source	Success rate; relevance; time-to-evidence; citation validity
Usability/efficiency	Natural-language interface, automation	Lower interaction effort	Over-complex dialogue, poor recovery	Task completion; error recovery; interaction burden
Personalization	Recommenders, user modeling	Reduced overload; tailored discovery	Filter bubbles; excessive profiling	Recommendation relevance; diversity; user control
Trust/transparency	Explanations, source-grounded responses	Better confidence calibration	Black-box ranking; anthropomorphic overtrust	Source visibility; explanation usefulness; trust calibration
Privacy/governance	Data-minimized personalization and analytics	Safer adaptive services	Logging, vendor reuse, sensitive-query exposure	Policy disclosure; retention; consent; incident rate
Accessibility/inclusion	Multilingual, voice, adaptive text	Broader access	Uneven language quality; inaccessible widgets	WCAG testing; language performance; assistive-tech success
Human support/literacy	AI triage + librarian escalation	24/7 first-line support with expert backup	Deskilling; hidden human alternatives	Escalation success; training; user AI literacy

Table 2. Proposed multidimensional UX framework derived from the evidence synthesis [2-10,21-29].

5. Discussion

The strongest cross-cutting finding is that AI is valuable when it reduces the cognitive and procedural effort required to move from an information need to a trustworthy resource. This is consistent with classic digital-library acceptance research, where usefulness and ease of use predict adoption [4,5], and with user-centered evaluation research emphasizing usability and collection quality [6-10]. AI can reduce friction through natural-language querying, semantic expansion, personalized ranking, automated metadata, multilingual interaction, and continuous reference support [16,20-23]. However, these advantages depend on the quality of the underlying collection, metadata, retrieval architecture, and access pathways.

This point is particularly important in the generative-AI era. A conversational interface can hide complexity, but it cannot compensate indefinitely for missing subscriptions, poor metadata, broken links, outdated holdings, or weak indexing. Cao and colleagues' findings on algorithm aversion show that users may attribute broad platform failures to the "algorithm," with system functionality and resource coverage becoming major drivers of resistance [25]. Libraries should therefore resist a front-end-only approach to AI modernization. Investment in clean metadata, persistent identifiers, link resolution, collection coverage, authentication reliability, and accessibility may produce greater UX gains than adding a sophisticated conversational layer to a weak infrastructure.

Conclusion

Artificial intelligence is becoming an important layer in the evolution of digital libraries, but its contribution to user experience is neither automatic nor uniformly positive. The evidence synthesized in this paper shows that AI can improve discovery, personalization, accessibility, response speed, and service availability, especially when natural-language processing, recommendation, and conversational interfaces are integrated with high-quality collections and metadata. At the same time, AI introduces new forms of uncertainty involving hallucinated information, opaque ranking, privacy, bias, uneven language support, algorithm aversion, and overreliance on systems that may appear more competent than they are.

The most durable conclusion is that the core determinants of digital-library success have not disappeared. Usefulness, ease of use, relevance, system functionality, collection quality, and service support remain central. AI adds value when it strengthens these characteristics, and damages UX when it obscures them. The finding that many deployed chatbots lack privacy disclosure, that complex retrieval remains challenging, and that librarians continue to report training needs demonstrates that technical adoption is ahead of institutional maturity in some settings.

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