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Digital Library

Concepts, Challenges, and Future Directions

Edited by Shuzhen Zhao



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Meet the editor



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Preface

Digital libraries have become integral to the contemporary knowledge ecosystem, reshaping how information is created, shared, accessed, and preserved. Advances in digital technologies, networked systems, and data-driven tools have extended the concept of the library beyond physical spaces and institutional boundaries, enabling new forms of scholarly communication, learning, and public engagement. At the same time, these developments raise important conceptual, technical, organizational, and ethical challenges.

The edited volume *Digital Library – Concepts, Challenges, and Future Directions* brings together contributions that examine digital libraries from diverse perspectives and contexts. The book aims to provide a balanced overview of foundational concepts, current challenges, emerging technologies, and the synergies shaping the development and use of digital libraries worldwide, reflecting the field's interdisciplinary and evolving nature.

The chapters address a broad range of topics, including digital library models and architectures, metadata and interoperability, digital preservation, user experience and accessibility, intellectual property and ethics, and the influence of emerging technologies such as artificial intelligence and data analytics. Collectively, they integrate theoretical perspectives with practical experiences drawn from a variety of institutional and cultural settings.

This book is the result of collaboration among researchers and practitioners from multiple disciplines, including library and information science, computer science, education, and the digital humanities. Contributors represent institutions from across the world, highlighting the global relevance of digital libraries and the need for context-sensitive approaches. The book's open-access nature aligns with the principles of knowledge sharing and inclusivity that underpin both digital libraries and IntechOpen's publishing mission.

Organized thematically, the book moves from conceptual discussions to applied challenges and future-oriented perspectives. It is intended for researchers, graduate students, and librarians. We hope this book will encourage continued dialogue, innovation, and collaboration in the study and practice of digital libraries within an open and accessible knowledge environment.

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AI Applications in Digital Libraries Facing Ethical Challenges and Privacy Concerns

Huda Abbas Kanber

Abstract

This study aimed to analyze the applications of artificial intelligence (AI) in digital libraries, with a particular focus on the accompanying ethical challenges and privacy concerns related to these modern technologies. The research adopted a descriptive–analytical approach, utilizing a specialized questionnaire as the primary data collection tool from a sample of 58 faculty members from colleges and departments of information systems and knowledge technology at three universities (Baghdad, Mosul, and Basra). The results revealed a positive trend toward adopting AI technologies, with plagiarism detection applications having the highest acceptance level (averaging 2.93), followed by machine translation tools and assistive robots (averaging 2.78). The findings also indicated a relative hesitance toward personal recommendation systems, which had an average score of 2.40. From an ethical standpoint, several key issues emerged, including concerns about privacy infringement (2.78), the absence of regulatory legal frameworks (2.53), and algorithmic bias (2.31). The study recommended implementing practical measures such as developing clear policies to protect users' data, strengthening transparency and accountability in algorithmic systems, training library staff on ethical AI practices, and conducting regular assessments of these technologies' impacts. It also emphasized the importance of learning from successful international models while adapting them to the local context. These suggestions aim to balance AI's potential with the preservation of academic values and users' rights in the digital environment, particularly in developing countries facing similar technological and ethical challenges.

Keywords: digital libraries, artificial intelligence, ethical challenges, privacy concerns, Information retrieval

1. Introduction

Artificial intelligence (AI) is the cornerstone of transforming digital libraries into the age of intelligence, revolutionizing how information is processed and services are delivered. These libraries increasingly depend on intelligent systems, such as automated metadata classification, semantic information retrieval, automatic

translation and summarization tools, chatbots, and AI-driven recommendation systems. However, this technological shift presents both theoretical and practical challenges, particularly regarding ethics and law. From a theoretical viewpoint, these applications raise crucial questions about privacy, transparency, and algorithmic justice. Collecting and analyzing user behavior data may violate privacy rights if not governed by clear ethical guidelines. Additionally, the reliance of AI systems on machine learning algorithms introduces the issue of algorithmic bias, potentially marginalizing certain user groups or content due to biases in training data. This study explores these challenges from a theoretical angle, analyzing the tension between AI's technological capabilities and the ethical and legal standards that should regulate its use in library settings. The research underscores the importance of regulatory frameworks that balance technological progress with the protection of user rights, grounded in theories of information privacy and digital ethics. It also demonstrates how digital libraries can harness AI's benefits while addressing key concerns related to data governance, algorithmic accountability, and equitable access to knowledge. AI is the cornerstone of the transformation of digital libraries into the era of AI, revolutionizing how information is processed and services are provided. These libraries are increasingly relying on intelligent systems, such as automated metadata classification, semantic information retrieval, automated translation and summarization tools, automated chatbots, and AI-managed recommendation systems. However, this technological transformation is not without theoretical and practical challenges, especially in the ethical and legal dimensions. From a theoretical perspective, these applications raise fundamental questions about privacy, transparency, and algorithmic justice. The collection and analysis of user behavior data may constitute a violation of privacy rights if not governed by clear ethical frameworks. In addition, the dependence of AI systems on machine learning algorithms raises the problem of algorithmic bias, since certain groups of users or content may be marginalized due to biases in training data. This study addresses these challenges from a theoretical perspective, analyzing the tension between the technological potential of AI and the ethical and legal requirements that should regulate its application in library environments. The research emphasizes the need for regulatory frameworks that balance technological innovation and the protection of users' rights, based on theories of information privacy and digital ethics. The research highlights how digital libraries can leverage the benefits of AI while addressing core concerns related to data governance, algorithmic accountability, and fair access to knowledge.

2. Literature review

The study by Bélanger and Crossler [1] aims to critically analyze the current state of Information Privacy Research in the field of information systems, highlighting its concept as a multi-level construction. Using the literature review methodology, the study examined scientific publications and relevant theoretical frameworks. It was noted that a large number of studies relied on samples of students and Americans, which limited the generalizability of the results. The results also revealed a heavy focus on theoretical explanations and predictions, with limited attention given to practical and design contributions. The study recommends that future research adopt a multi-level analytical approach, diversify sample populations, and

emphasize the development of practical tools and IT solutions aimed at enhancing information privacy and user control.

The study by Al-Azzawi [2] aims to define key ethical principles in the information age and how they are applied in the General Secretariat of the Central Library at the Universities of Baghdad, Mustansiriyah, and the University of Technology via a questionnaire completed by 125 of the 227 employees. It addressed the relationship between ethics and human interactions within the library work environment, as well as key problems facing information specialists regarding qualifications, pressure, and work conditions. The study found that ethical rules significantly affect service quality and user satisfaction. It is recommended to introduce a dedicated course on professional ethics and ensure a stable, creativity-stimulating work environment.

The study by Ikwuanusi et al. [3] aims to analyze the role of ethical AI practices in protecting user data privacy within academic libraries, as AI adoption grows to enhance library services. This topic is important because libraries gather large amounts of personal data, making them vulnerable to risks such as data breaches and misuse. The study *emphasizes key ethical AI principles – user consent, data ownership, and bias mitigation* – including privacy-preserving techniques such as federated learning and differential privacy. It also emphasizes the importance of transparency through explainable AI (XAI) and compliance with regulations such as General Data Protection Regulation (GDPR) and CCPA. Practical case studies demonstrate how libraries can balance privacy and personalization. It recommends international collaboration and open-source tools to secure data and uphold user trust in digital libraries.

The study by Ali [4] aims to highlight the role of AI applications in protecting data privacy, based on the guidelines of the American Library Association (ALA), especially in the application of Library Management Systems. The importance of the study lies in the lack of research addressing this vital topic. It adopts the descriptive and analytical case study method and discusses concepts such as AI, transparency, and privacy. The findings concluded that AI is a central tool in safeguarding data confidentiality within libraries. The study suggests that the library should consider embracing a model that aligns with the guidelines set forth by the ALA to enhance its strategic planning. A phased implementation approach would be most effective, allowing the library to introduce these new procedures at a pace that suits its unique situation and resources.

The study by Abudulsalami et al. [5] explores how AI is being adopted in academic libraries, examining its impact on both library services and internal operations. Based on a review of contemporary studies and available statistical evidence, the study aims to identify the main challenges and opportunities associated with the application of AI technologies in academic environments. The study highlights the practical uses of AI, such as chatbots, personal recommendation tools, and data-driven decision-making, and assesses its role in improving user interaction and streamlining library workflows. Through a structured theoretical perspective and focused research, the study aspires to enrich the existing scientific debate on AI in libraries and provide practical guidance to librarians, institutional leaders, and decision-makers.

The study by Arunachalam et al. [6] addresses issues of privacy and security in digital libraries, especially in light of the increasing dependence on digital systems for storing, organizing, and providing access to information. The main objective of

the study is to analyze the technical and ethical challenges associated with the protection of user data and digital content, focusing on the need for a secure and efficient infrastructure. The study adopts a descriptive-analytical approach through a comprehensive review of the relevant scientific literature, highlighting previous studies on digital security and privacy policies in library environments. The results indicate that the absence of uniform policies and weak technical regulations poses significant threats to data confidentiality and integrity. The study emphasizes the importance of using technologies such as encryption, identity verification, and regular data backup, as well as training library staff on cybersecurity measures. The study recommends the establishment of clear regulatory frameworks and strengthening cooperation between libraries at the national and international levels to exchange best practices and standardize standards related to information privacy and security.

The study by Hodonu-Wusu [7] addresses how libraries have always been a source of knowledge and a place of learning, and in today's fast-paced, technology-driven world, they must adapt to maintain their relevance. AI is a promising tool that can help libraries automate processes, provide customized services, and improve user experiences. However, AI must be used ethically and fairly, respecting the obligations of libraries to their users. The study explores how AI can empower users and what librarians should consider when implementing it. A review of the literature revealed that 1,499 out of 170,262 research papers addressed AI in libraries from an ethical and equitable perspective. The study suggests that future research should focus on concepts such as trustworthy and fair AI, interpretable AI, and human-in-the-loop, and how these concepts can affect library environments.

The study by Wang and Xia [8] indicates that AI technologies are rapidly developing across various sectors, yet research on their applications in libraries remains relatively limited. A steady increase was observed in the number of studies related to AI in libraries between 2015 and 2024, with research articles being the most common type of publication in this field. This type of research is often focused on computer science, while medical journals, most notably the *Journal of Medical Internet Research*, appear to be the most prominent platforms for publishing works on AI in the context of libraries. The United States, China, the United Kingdom, and Canada are among the leading countries in this field. The study also reviewed models of AI use in interactive university libraries, particularly in areas such as information retrieval and education, emphasizing the importance of developing librarians' skills to enable them to leverage the potential of AI within the library environment effectively.

The study by Nathania et al. [9] aims to show that libraries have always been a source of knowledge and a place of learning, and in today's fast-paced, technology-driven world, they must adapt to maintain their relevance. AI is a promising tool that can help libraries automate processes, deliver personalized services, and enhance user experiences. However, AI must be used ethically and equitably, respecting libraries' obligations to their users. The study explores how AI can empower users and what librarians should consider when implementing it. A literature review revealed that 1,499 of the 170,262 research papers examined AI in libraries from an ethical and equitable perspective. The study suggests that future research will focus on concepts such as trustworthy AI, fairness in AI, XAI, and human-in-the-loop approaches, and how these concepts might impact library environments.

This study stands out for its practical field research, delving into the real-world application of AI within Iraqi digital libraries. By analyzing feedback from a targeted group of faculty members specializing in information and knowledge technologies, it offers a unique local perspective rarely explored in prior research. Unlike much of the existing literature, which tends to center exclusively on either technical or ethical aspects, this research bridges the gap by examining smart applications alongside their ethical implications and privacy concerns. Employing statistical tools, the study uncovers trends and relationships between variables, showcasing a meticulous and well-rounded approach.

3. Methodology

This study adopted the descriptive-analytical approach to explore the extent of AI applications in digital libraries and examine the ethical and privacy concerns associated with them. A questionnaire was used as the main data collection tool and was distributed to a random sample of 58 faculty members specializing in information systems, knowledge technologies, and digital libraries. To ensure the authenticity and clarity of the tool, it underwent a review and audit process by a committee of academic experts in the fields of Information Science and digital technologies (Appendix 1). Their feedback was taken into account to enhance the authenticity of the content of the tool and its linguistic accuracy. The survey aimed to identify the AI tools used, assess the level of their application in the main Iraqi university libraries, and highlight ethical issues such as transparency, algorithmic bias, and privacy risks related to data collection and analysis. Data were analyzed using descriptive statistical methods, including arithmetic means and standard deviations, to detect trends in the participants' responses. A three-point Likert scale (Agree = 3, Neutral = 2, Disagree = 1) was employed to evaluate the relationships between certain demographic variables and the participants' perspectives.

4. Operational definitions

4.1 Digital libraries

Many concepts and terms synonymous with the electronic library have emerged, including Electronic Library, Hybrid Library, Virtual Library, Library of the Future, Library without Walls, *and* Online Library. These terms reflect the evolving nature of libraries in response to technological advancements. The term “digital” refers to data transmitted as discrete and non-continuous electrical signals, represented in binary code (zeros and ones). Meanwhile, “digitization” refers to the process of converting data within information systems into digital form, such as transforming printed texts or images into digital signals using scanning devices [10, p. 202].

[11] Defined the digital library as an institution in which all functions are carried out electronically or digitally, including resource acquisition, cataloging, indexing, information searching, and retrieval, as well as a wide range of reference services.

[12] Described as a collection of electronic information resources available on the library server, accessible through a local network or via the Internet [13, p. 72].

A digital library is one whose policy aims to expand its collection of digital resources,

whether born-digital or converted into digital format (digitized). These resources are bibliographically controlled, organized, and preserved using a fully integrated automated system that provides advanced tools and techniques for information search and retrieval, whether at the metadata level or the content level. Access to internal and external repositories and digital services is made possible through computer networks, either locally or via the Internet [14]. Defined digital libraries as virtual platforms that collect, organize, and provide access to digital materials, such as e-books, scholarly articles, and historical documents. They are designed to offer users either free or licensed access to a broad range of resources, without the constraints of physical access. These libraries often rely on collaboration with various institutions to manage intellectual property rights and ensure the long-term preservation of content. Their key characteristics include open accessibility, global reach, and the integration of both newly digitized and born-digital materials.

From the previous definitions, we conclude that digital libraries provide electronic information resources – whether created in digital form or digitized from physical materials – through computer networks, whether local or online. These libraries operate through fully automated processes that cover the acquisition, cataloging, indexing, retrieval, and delivery of information services. They represent a modern approach to information access, removing physical barriers and relying heavily on digital technologies.

In parallel, digital libraries must address growing concerns around user privacy and ethical responsibility. Protecting personal data and ensuring the confidentiality of search behaviors are fundamental obligations. Additionally, issues such as intellectual property rights, fair use of content, and digital responsibility require libraries to follow established legal and professional frameworks to maintain trust and uphold ethical standards in the digital age.

4.2 Artificial intelligence

The term “Intelligence” is linguistically defined as sharpness of the mind, quick wit, and the ability to understand [15, p. 374]. The term “Artificial” is defined as the ability to analyze, synthesize, distinguish, choose, and adapt to various situations [16, p. 314]. It also refers to anything that is man-made or not naturally occurring, such as artificial flowers, synthetic silk, or artificial satellites [15, p. 82].

AI is defined as the science that enables machines to make decisions and act intelligently by simulating humans and their ways of thinking [17, p. 7]. John McCarthy, known as the father of AI, defined it as “the science of engineering intelligent machines” [18].

It has also been defined as “the process of simulating human intelligence through computer systems by attempting to replicate human behavior, thought patterns, and responses to different situations” [19, p. 62]. AI refers to the ability of computer-based systems to carry out functions commonly linked to human intelligence, including learning, reasoning, problem-solving, perception, and decision-making. As a branch of computer science, AI focuses on designing and analyzing algorithms and programs that allow machines to interpret their surroundings, adapt through learning, and take actions aimed at optimizing the achievement of specific objectives [20].

AI is the capability of computers and programmed machines to execute functions that usually require human-like cognition. This encompasses the ability to analyze

information, interpret concepts, adapt based on prior experiences, and develop abstract patterns. Although computers have been used since the 1940s to handle complex operations such as theorem solving and chess, they still lack the full adaptability of human intelligence across broad situations. Nonetheless, in specific domains, AI has reached expert-level performance. Examples include medical assessments, information retrieval, voice and handwriting recognition, and human-computer interaction tools. In such focused applications, AI has proven both efficient and reliable [21].

Researchers describe AI as an interdisciplinary scientific domain connected to computer science and software technologies. It encompasses the capacity of systems to mimic human cognitive functions – such as perception, reasoning, learning, and decision-making – by analyzing and interpreting data. These systems operate using structured databases that support problem-solving and adaptive responses, allowing them to perform tasks that typically require human-like intelligence.

4.3 Ethical challenges

The term (challenges) refers to the obstacles or dangers that individuals and societies face. A *challenge* often provokes opposition or resistance. The concept of “challenge and response” is a theory in the philosophy of history that posits that civilizations arise when a people confront a serious threat to their existence and respond to it with intensified efforts driven by a desire for survival [22, p. 461]. The term (ethics) refers to a set of traits and actions characterized as either virtuous or immoral. *Social ethics* reflect the customs and values embraced by a given community. Meanwhile, the word (ethicality) is a nominal derivative of “ethics” and is used to describe the emerging global mindset shaped by new ethical standards. The phrase “work ethics” encompasses all moral principles and standards associated with professional conduct [22, p. 688].

Ethical challenges are defined as a set of dilemmas or complex situations that place individuals or institutions in positions where decisions must balance what is legal, what is just, and what is morally responsible. These decisions are often unclear and may involve conflicts between different ethical principles [23, p. 9]. It shows [24, p. 6] ethical challenges related to the privacy and security of data and raises concerns about whether the existing compliance and security mechanisms would suffice in securing the data in the transforming nature of emerging technologies. The ethical implications of cloud computing are influenced by several technological factors such as security, privacy, compliance, performance metrics, and so on.

Ethical challenges also refer to situations or issues in which individuals, institutions, or professionals encounter moral conflict or ambiguity, making it difficult to determine the appropriate course of action. Such challenges often require making a choice between competing ethical options or outcomes, necessitating wisdom and careful judgment to weigh and reconcile conflicting moral values. In the general context, ethical challenges include issues such as:

- Privacy and data protection;
- Fairness and discrimination;

- Transparency and accountability;
- Integrity and fraud;
- Exploitation or unintended harm.

4.4 Privacy concerns

The term (concerns) refers to the plural of (fear), denoting perceived dangers, risks, or worrisome possibilities that individuals believe may result in harm to themselves or others [25, p. 3,458]. Among the most prominent of these are *privacy concerns*, which arise when individuals sense that their personal information may be subject to collection, use, or disclosure without their prior consent.

The concept of *privacy* encompasses various dimensions, including *confidentiality, particularity, singularity, exclusiveness, and distinct personal features*. This perspective is further reinforced by Margulis [26], who presents privacy as a self-regulatory mechanism through which individuals exercise control over their data sharing to preserve autonomy and reduce the potential risks of personal data exposure. Privacy is defined by Westin [27] as a protective capacity that enables individuals or groups to control access to their data and prevent its exposure or misuse by others – especially institutions – unless they voluntarily choose to disclose it.

In a similar vein, Waldo et al. [28, p. 59] describes privacy as: “The claim of individuals, groups, or institutions to determine for themselves when, how, and to what extent information about them is communicated to others.”

Privacy is thus intrinsically linked to human identity, representing a personal domain through which individuals safeguard their thoughts, emotions, and personal secrets that constitute their uniqueness. The right to privacy, therefore, ensures that individuals can live independently from intrusion, which supports their psychological and emotional well-being, whether in their personal lives, social environments, or interpersonal relationship. [29, p. 179].

Building on this, Bélanger and Crossler [1] define privacy concerns as follows:

The degree of anxiety individuals feel about the collection and use of their personal information by organizations is significant. Protecting privacy has become a cornerstone of digital rights, contributing to the reduction of risks stemming from data misuse. It also supports the creation of a legal environment that guarantees individuals’ right to privacy without contradicting their right to internet access or technological advancement [30, p. 15]. Informational privacy, in particular, refers to safeguarding personal data in digital environments. Such data may include email addresses, bank account numbers, phone numbers, photographs, and other forms of digital identity [31, p. 419]. It has also been defined as:

“The ability to maintain one’s personal space and protect it from interference by individuals or institutions” [32, p. 112].

Privacy concerns reflect the apprehensions individuals experience when they believe their personal information may be collected or used without explicit consent, particularly within digital or institutional settings that rely on data-tracking technologies. This often leads to a perception of diminished control over one’s data and uncertainty about how it may be used.

The main dimensions of privacy concerns include:

- Transparency – the lack of clarity regarding how personal data is used.
- Consent – data is being collected without prior authorization.
- Security – fears of data breaches or unauthorized access.
- Control – inadequate access to update or erase personal information.
- Misuse – concerns about data being used for commercial or security purposes without the user's knowledge.

In the context of digital libraries, privacy concerns refer to users' apprehensions regarding how their personal information and digital behavior are collected during their interaction with services such as electronic borrowing, search logs, and user account data. These concerns arise from the potential use of this information for undisclosed purposes, such as analytics, marketing, and surveillance. This presents a considerable ethical dilemma for libraries, which are expected to uphold user confidentiality and trust amidst the swiftly advancing digital technologies.

5. Applications of AI in digital libraries

5.1 Intelligent metadata automation and source classification tools

Digital libraries are leveraging AI tools to automate cataloging and classification, reducing human error and improving operational efficiency. Machine learning algorithms analyze content, generating accurate metadata, creating subject headings, and automatically classifying materials based on textual content. This minimizes manual effort and speeds user access to relevant resources. Natural language processing (NLP) technologies enable texts to be precisely analyzed, interpreted, and categorized, supporting intelligent resource organization. These tools have significantly improved the accuracy of object descriptions and the ease of finding resources, helping researchers and users quickly locate relevant content. For example, Harvard University Library uses an AI metadata assistant integrated with the Alma platform to automatically generate and validate metadata by analyzing content, images, and documents. This decreases the time needed to create or enhance records and allows for human review and validation [33]. Similarly, OCLC introduced the AI-enhanced service WorldShare AI, which suggests subject headings and automatically classifies materials within cataloging records, speeding up the classification process and reducing human errors [34]. In the Arab world, Qatar National Library has adopted intelligent tools to automatically classify multilingual resources [35]. King Abdulaziz Public Library in Saudi Arabia uses AutoCat technology to improve Arabic book cataloging, with positive preliminary results [36, 37]. The Central Library of the University of Baghdad has implemented the KOHA system [38], an open-source library management system, to develop its automated catalog. KOHA helps organize both digital and print resources and enhances access efficiency through an advanced user interface and flexible search options.

5.2 Intelligent information retrieval systems

Modern digital libraries rely on AI-powered information retrieval systems to enhance the accuracy and speed of responding to research queries. These systems analyze user queries using machine learning techniques and retrieve highly relevant results based on semantic context rather than simple keyword matching. These technologies fit within the framework of modern neural ranking models. A significant example of such advancement is the augmented search generation (retrieval-augmented generation [RAG]) technique, which combines knowledge bases and dense vector representations to improve ranking accuracy and expand search scope. For example, MIT Libraries has developed an AI-powered search platform that delivers more accurate results and recommendations based on user behavior analysis, thus enriching the search experience [39]. Similarly, the Stanford University Libraries implemented a semantic search system capable of understanding user queries and matching them to relevant document content, even when phrased differently, leading to significantly improved retrieval results [40]. At North Carolina State University (NCSU), the library utilizes an integrated robotic system known as bookBot for smart storage and retrieval of physical books. Users request items via an electronic interface, and the system retrieves and delivers the books automatically with minimal human intervention [41]. Likewise, the Berlin Public Library employs an AI-enhanced Elasticsearch engine to improve electronic book retrieval [42]. In the Arab context, Dubai Smart Library has implemented an NLP-based search system to handle research inquiries in Arabic [43], while the Library of Alexandria uses a semantic search engine to enhance the retrieval of historical documents [44].

5.3 Machine translation and text summarization tools

Digital libraries utilize modern machine translation tools to deliver multilingual content quickly and accurately, enabling users to access documents in foreign languages without having to wait for full human translations. These technologies rely on pre-trained neural networks (Neural Machine Translation – NMT), such as the T5 model, to produce fluent and highly readable translations [45]. At the same time, Automatic Text Summarization (ATS) offers effective solutions for handling vast amounts of digital content by generating concise summaries that capture key ideas without requiring users to read the entire document. Abstractive summarization models use AI-enhanced architectures to produce meaningful, condensed texts [46]. These intelligent tools have proven effective in accelerating content comprehension, reducing research time, and allowing users to instantly access summaries or translations without going through full texts. Such applications support researchers and assist librarians in delivering advanced knowledge services within digital environments. For example, the University of Oxford Library uses DeepL Translator to translate rare books into multiple languages [47]. The New York Public Library (NYPL) employs GPT-3 to summarize scholarly articles [48]. In the Arab world, the King Fahad National Library (KFNL) uses the Google Translate API to translate scientific resources [49], while King Saud University Library utilizes an Arabic Text Summarization program to provide summaries for lengthy research papers [50].

5.4 Chatbots and virtual assistants for user services

Chatbots have emerged as one of the most prominent applications of AI in digital libraries, providing immediate responses and continuous support to users via text or voice chat platforms. These AI-powered assistant robots leverage NLP and machine learning technologies to accurately understand queries and provide precise answers, enhancing service efficiency and reducing staff workloads. Many countries have implemented intelligent chatbot technologies in their library systems. China has deployed “Tu Bao” robots at Nanjing University Library to greet visitors and guide them to information resources [51]. In the United Kingdom, the University of Birmingham introduced “Bob,” a robotic assistant that monitors table cleanliness and identifies maintenance needs within library facilities [52]. Aberystwyth University developed “Hugh,” a technical specialist robot capable of processing user requests and locating books through RFID technology [53]. Similar progress has been made by academic libraries in India, where several robotic librarian assistants were launched in 2018 to provide information services and support in library environments [54]. In the Arab world, leading libraries have embraced this technology to enhance their services. The Bibliotheca Alexandrina employs “AskBibalex,” powered by Rasa NLU technology, to facilitate access to digital archives and answer user inquiries [44]. King Abdullah University of Science and Technology (KAUST) Library developed a WhatsApp-integrated chatbot using Dialogflow for ebook renewals and membership queries with exceptional accuracy [55]. Qatar National Library offers a virtual assistant based on IBM Watson for catalog searches, while Dubai Public Library uses Microsoft Bot Framework for e-book reservations and reading recommendations [35].

5.5 AI-based recommendation systems

These systems evaluate user behavior and interest trends – such as search and borrowing history – to provide tailored recommendations for books and articles. They utilize models including Collaborative Filtering, Content-Based Filtering, and sophisticated algorithms like Matrix Factorization and Deep Learning to generate precise suggestions aligned with user preferences. Libraries across the globe, including both international and Arab institutions, are embracing these technologies. The New York Public Library (NYPL) has created a recommendation system employing algorithms akin to those used by Netflix, offering accurate suggestions based on users’ borrowing histories [48]. Likewise, the University of Toronto Libraries apply collaborative filtering to personalize recommendations for academic and literary books [56]. In the Arab region, the Cairo University Library has integrated a system that analyzes researcher behavior to suggest relevant academic resources [54]. The KFNL in Saudi Arabia uses AI-powered recommendation tools to offer personalized reading lists and integrates them with self-checkout systems to enhance the user experience [49].

These intelligent systems are transforming library services by enhancing book utilization, elevating user satisfaction, and fostering greater engagement with library materials. When integrated with university Learning Management Systems (LMS), they establish a sophisticated academic setting.

5.6 AI-based plagiarism detection

Digital platforms utilize AI-driven tools to identify plagiarism by examining texts and extensive databases. These tools employ NLP methods and guidelines for recognizing copied material, including paraphrased or summarized content. They focus on maintaining academic integrity within digital libraries by offering swift and precise detection of unoriginal or erroneous content. The objective of these library tools is to deliver thorough, detailed services for academic documents prior to publication or approval, pinpointing what may go unnoticed and upholding user ethics. The services provided encompass linguistic consistency evaluation, citation monitoring, and in-depth reports, thereby offering extensive assistance to both researchers and librarians. Numerous academic libraries globally, including Syracuse University Library and the National University of the Interior Library, utilize Turnitin to identify plagiarism and confirm the originality of content. Likewise, leading Arab institutions such as Iraqi universities, Mansoura University in Egypt, and the University of Jordan employ the same systematic approach [57]. These institutions engage students and faculty members in training programs to ensure reliable review processes and reduce plagiarism to acceptable levels. These systems provide detailed reports that help promote academic integrity and ensure the quality of research outputs within digital library environments.

5.7 User behavior analytics tools

Modern digital libraries are increasingly relying on user behavior analytics through tools such as Google Analytics, LibInsight, and others to evaluate website and service effectiveness and inform decisions related to interface design and content organization. At Boise State University (Albertsons Library), the library used the “events” feature in Google Analytics to track users’ navigation paths, identify drop-off points, and analyze actual clicks on library resources. This led to a drop in bounce rates to below 10% and a notable improvement in user interface design after a complete overhaul [58]. Similarly, a case study at Texas Tech University Libraries revealed a significant gap between design expectations and actual site performance. Usage analytics via Google Analytics were used to assess real user interactions with content, helping guide decisions based on actual behavior rather than prior assumptions [59]. At the Arab regional level, a study [60] indicated that Saudi academic libraries have increasingly adopted big data analytics to assess user engagement with library services, predict future needs, and guide content acquisition decisions, all contributing to the continuous enhancement of library service quality.

5.8 Other applications

Libraries are increasingly adopting virtual and augmented reality (VR and AR) technologies to offer interactive experiences. For example, Stanford University Library provides virtual tours of its historic halls, while IIM Ahmedabad University Library in India has developed a VR application called Sahel that allows users to navigate the library in a fully immersive environment. The Dubai Future Library uses AR to present interactive books that enhance user engagement. In the domain of image and video recognition, the Library of Congress utilizes Google Vision AI to

classify and tag archival images. Smart audiobooks have now become a tangible reality, as KAUST implements intelligent tools to efficiently manage digital content and audio resources. In the realm of sentiment analysis, Harvard University Library utilizes IBM Watson to evaluate user feedback, while the Bibliothèque nationale de France (National Library of France) employs Transcribe to interpret manuscripts. Qatar National Library utilizes AI-driven systems to accurately catalog Arabic manuscripts. Intelligent archiving systems also play a crucial role in the preservation of documents. The UAE National Archives uses AI to automate the archiving of government records, thereby ensuring long-term digital preservation. In the domain of smart education, MIT Libraries provide AI-enhanced virtual workshops to facilitate learning. Furthermore, Tsinghua University Library in China implements an advanced Digital Rights Management (DRM) system that utilizes AI to analyze user behavior and prevent unauthorized access to academic content. This system combines machine learning with blockchain technology to protect digital rights and securely log user activity.

These cutting-edge applications reflect a global trend toward transforming libraries into intelligent knowledge hubs that offer personalized, secure experiences while preserving cultural and scientific heritage. **Figure 1** shows the above applications.

6. Foreign and Arab laws on the protection of information privacy in digital libraries

In light of the rapid shift toward digital libraries and the employment of AI technologies, there has been an urgent need to establish legal and legislative

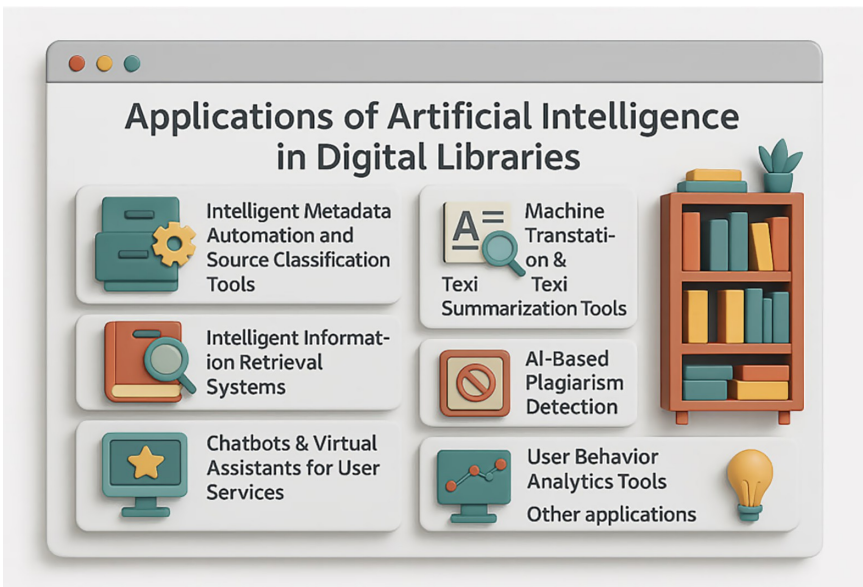


Figure 1.
Applications of artificial intelligence in digital libraries.

frameworks that regulate data privacy and protect user rights. American and European laws are at the forefront of these initiatives; the ALA emphasizes the importance of adopting explicit policies for the confidentiality of beneficiary data, requires limiting the retention of personal information, and mandates obtaining user consent before collecting or analyzing their digital behavior [61].

At the European level, the GDPR is considered one of the strictest privacy laws globally and entered into force in May 2018. The regulation obliges institutions, including digital libraries, to obtain clear consent from users before collecting or processing their data and grants them extensive rights, including access to data, requesting correction or deletion, and objecting to its use. It also requires notification of any security breach within 72 hours and reinforces the principle of “privacy by design.” The regulation has been extended to include institutions outside the European Union if they deal with the data of its citizens, meaning that it also applies to digital libraries in Asia or the Arab world that partner with Europe. In the European context, the Privacy Directive is particularly significant as it governs the use of tracking mechanisms, including cookies, and mandates explicit consent for technologies that assess user behavior. National legislation in Europe, such as the German Data Protection Act (BDSG), complements the GDPR, imposing strict standards for the protection of digital data, including data stored electronically in libraries, and holding institutions legally liable in the event of a breach. [62]

International organizations, such as the Organization for Economic Co-operation and Development (OECD) and the International Federation of Library Associations and Institutions (IFLA), have also called for clear governance frameworks that include privacy impact assessments (PIAs), external audits, and transparent policies for patrons in the digital environment [63]. In Asia, Japan’s Act on the Protection of Personal Information (APPI), first enacted in 2003 and subsequently amended in 2020 and 2022, is among the first progressive laws in this area. It requires explicit user consent and grants individuals the right to modify or delete their personal data [64]. The European Union recognized it as equivalent to the GDPR in 2019. In South Korea, the Personal Information Protection Act (PIPA) is considered one of the most comprehensive laws, requiring immediate notification in the event of breaches and obliging institutions to appoint a data protection officer. It received official European recognition in 2021. In China, the Personal Information Protection Law (PIPL) was enacted in 2021. It intersects with the GDPR in terms of fundamental rights such as correction, deletion, and withdrawal of consent, but it requires institutions to store data domestically and allows fines of up to 5% of revenues for violators. In Singapore, the Personal Data Protection Act (PDPA) has regulated data protection since 2012 (with a major amendment in 2020), emphasizing transparency and prior consent, although it does not grant the full right to deletion as in the GDPR [65, 66]. India is the latest Asian country to adopt this framework, having passed the Digital Personal Data Protection Act (DPDP Act) in 2023, which is inspired by the European regulation [67]. The act grants users comprehensive rights and imposes fines on violators. At the regional cooperation level, the APEC CBPR framework stands out, involving nine countries from Asia and the Pacific, allowing cross-border data transfers under strict privacy protection conditions.

As for the Arab region, countries have recently begun issuing data protection laws in line with international standards. In Saudi Arabia, the Personal Data Protection Law was issued in 2022. It requires entities to collect data only with explicit consent and gives users the right to access, correct, delete, and object, and obliges institutions to

conduct impact assessments and appoint a data protection officer [68, 69]. In Egypt, literature reviews have shown that digital libraries need clear policies for managing user data and organizing contracts with cloud service providers. A study published in the *International Journal of Library and Information Science* recommended detailed regulations to protect privacy in the digital library environment (Labib & Al-Saeed).

7. Ethical challenges and privacy concerns in the use of AI tools in digital libraries

7.1 Digital privacy and user data protection in smart libraries

Digital privacy and user data protection are among the most pressing ethical challenges in digital libraries, particularly with the growing reliance on AI technologies that collect and analyze user data – such as search history, browsing behavior, and research interests – to personalize services and enhance the user experience. However, this extensive data collection, when done without sufficient transparency or explicit consent, poses significant risks to personal privacy. Research conducted by Hwang and Hanson [70] revealed that a lack of robust data protection policies heightens user anxiety and diminishes trust in libraries. This underscores the necessity of implementing the “Privacy by Design” (PhD) principle and performing PIAs. Additionally, organizations such as IFLA and the OECD advocate for the integration of these principles into digital transformation strategies to protect user rights and reduce the risks associated with data breaches and misuse. Furthermore, regulations such as the EU GDPR impose legal obligations to implement these safeguards, making it a model framework for digital libraries globally [71]. In the Arab context, a study by Labib and Saied [61], published in the *International Journal of Library and Information Science*, emphasizes the existing institutional deficiencies in data protection policies across Arab digital libraries. It advocates for the establishment of a thorough legislative framework to govern user privacy in line with technological progress.

7.2 Algorithmic bias and information inequality in digital libraries

Algorithmic bias and information inequality represent critical challenges in the application of AI tools within digital libraries. Recommendation and classification algorithms may unintentionally reinforce cultural or linguistic biases when trained on imbalanced or non-representative datasets. This often results in the marginalization of literary or academic content that reflects local voices or underrepresented communities, while favoring globally dominant sources and languages. To address this, IBM has developed the AI Fairness 360 (AIF360) toolkit, which provides a set of algorithms and metrics to detect and mitigate bias in AI models [72], making it a key resource for promoting objectivity in library systems.

[73] In their study published in the *Journal of Information Ethics*, they emphasized the importance of continuously auditing digital library algorithms to identify and correct bias pathways, ensuring equitable access to information. They advocate for inclusive development teams – comprising librarians, data scientists, and end users – to create fairer recommendation systems. Recent literature also stresses the need to integrate fairness principles into the design and deployment of AI in libraries to protect diversity, representation, and informational justice.

7.3 Data security and information confidentiality

Digital libraries are increasingly encountering risks associated with the storage and security of user data, especially when AI systems are incorporated into their infrastructure [74]. It is emphasized that inadequate encryption protocols or the lack of multilayered protection mechanisms can leave user data – such as search logs and personal information – vulnerable to breaches or leaks. Advanced privacy-preserving techniques, such as Federated Learning, which retains user data locally while only sharing trained models, and Differential Privacy, which adds statistical noise to mask individual identities, have been recognized as effective tools for mitigation. According to El Mestari et al. [75], the implementation of these methods significantly diminishes systemic vulnerabilities and fosters public trust in AI-driven digital library systems.

7.4 Ethics of smart operations

The growing reliance on AI technologies – such as automated cataloging, recommendation systems, and virtual assistants – in libraries has raised concerns about the potential decline of human librarians' roles and importance [70]. It is warned that excessive automation might undermine human intellectual judgment and diminish the quality of interactions between patrons and library services. To address this, the concept of “Human Intervention in Literacy” (HITL) is promoted as a strategic ethical framework that ensures human involvement in critical AI-driven decisions. This includes tasks like reviewing AI-generated recommendations and validating classification results, which can enhance service quality and improve librarians' effectiveness. Maintaining human oversight not only safeguards the ethical aspects of information access but also reinforces the librarian's vital role as a custodian of knowledge.

7.5 Digital governance frameworks

Despite the growing adoption of AI in libraries, many institutions still lack clear governance frameworks to guide their implementation, which are essential for ensuring transparency, fairness, and accountability. Reviews by organizations like the OECD and standards such as ISO/IEC 22989 and ISO/IEC 42001 [76] highlight that libraries and cultural institutions often struggle to operationalize responsible AI principles effectively [77, 78]. The concept of “Programmable Ethics” is proposed, suggesting that ethical rules be directly embedded within AI systems, complemented by ongoing human oversight. This approach integrates ethical considerations into AI development and institutional policies, creating a strong foundation for governing smart technologies in libraries, ultimately fostering public trust and promoting responsible, conscious deployment of AI tools.

8. Results and discussion

The researcher used the questionnaire as the primary means of collecting data to achieve the research objectives. To ensure the validity of the tool, the questionnaire,

consisting of 35 indicators distributed across four areas, was presented to a group of experienced and specialized arbitrators (Appendix 1), numbering five arbitrators from different specializations. This step is considered one of the approved methods for verifying apparent validity, as the tool model is presented to a group of specialized experts to express their opinions on the suitability of the paragraphs to measure the targeted phenomena. After analyzing the arbitrators' opinions, it was found that there was a 95% agreement on the validity of the questionnaire paragraphs, which confirms that they enjoy a high degree of validity, and thus they are ready for field application. The following is an analysis of the response data extracted from the questionnaire:

8.1 Demographic information

Table 1 showed that the majority of the sample members were female (63.79%), compared to 36.21% male participants. PhD holders represented the highest proportion at 58.62%, followed by Master's degree holders at 41.38%, with no participants holding a higher diploma. Regarding academic rank, the sample was

No.	Item	University of Al-Mustansiriyah	University of Mosul	University of Basrah	Total	Percentage (%)
1	Gender					
	Female	23	8	6	37	63.79%
	Male	7	6	8	21	36.21%
2	Academic qualification					
	PhD	25	6	3	34	58.62%
	Master's	5	8	11	24	41.38%
	High Diploma	-	-	-	-	0.00%
3	Academic title					
	Professor	3	2	3	8	13.79%
	Associate Professor	14	3	1	18	31.03%
	Lecturer	9	4	3	16	27.59%
	Assistant Lecturer	4	5	7	16	27.59%
4	Scientific specialization					
	Library and Information Science	22	12	12	36	62.07%
	Information and Knowledge Technologies	18	-	2	20	34.48%
	Other	-	2	-	2	3.45%
5	Years of experience in field					
	Less than 5 years	2	3	2	7	12.07%
	5–10 years	6	5	9	20	34.48%
	More than 10 years	22	6	3	31	53.45%

Table 1.
Demographic information of the study sample.

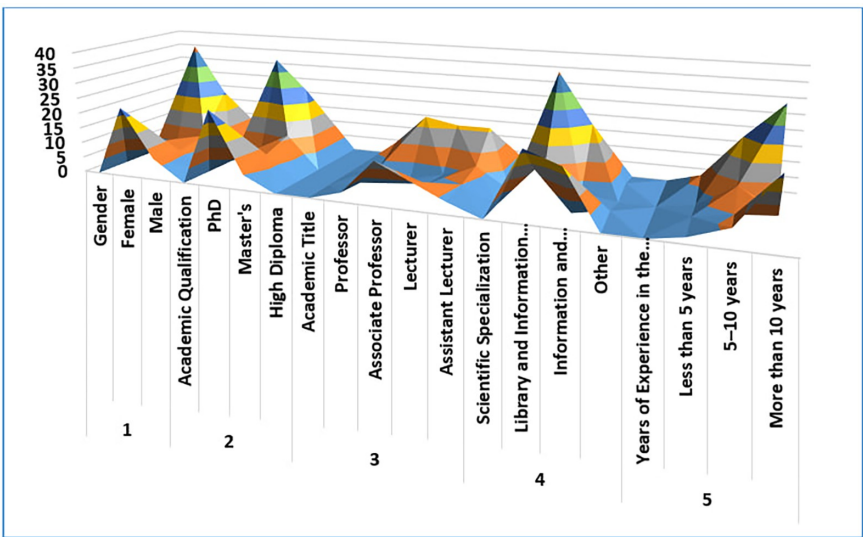


Figure 2.
Demographic information of the study sample.

distributed as follows: Assistant Professors (31.03%), Lecturers (27.59%), and Assistant Lecturers (27.59%), while Professors accounted for 13.79%. In terms of specialization, the majority of participants were from the “Information and Library Science” field (62.07%), followed by “Information and Knowledge Technologies” (34.48%), and others (3.45%). As for professional experience, those with more than 10 years of experience constituted the largest group (53.45%), followed by those with 5–10 years of experience (34.48%), and finally, those with less than 5 years (12.07%). These findings reflect a well-balanced and qualitatively representative sample of experienced faculty members specialized in Information Science. **Figure 2** illustrates these results.

8.2 Applications of AI in digital libraries

The analysis of the data in **Table 2** revealed a high level of agreement among participants regarding the effectiveness of AI applications in enhancing digital library services. The mean scores for most items ranged between 2.55 and 2.93, indicating a generally positive attitude toward the adoption of AI technologies. The highest level of agreement was observed for the item related to “plagiarism detection,” which recorded a mean score of 2.93 and a low standard deviation of 0.25, reflecting strong consensus on the importance of this tool in maintaining academic integrity. Other tools, including real-time translation, text summarization, chatbots, and user behavior analysis, garnered significant support, each attaining a mean score exceeding 2.5. Conversely, the aspect related to “personalized recommendation systems” was the sole item to elicit a neutral response (mean = 2.40), indicating a degree of reluctance among some participants regarding the implementation of personalized algorithms. In summary, the results reflect a distinct sense of optimism and a positive view of the contribution of AI in

No.	Statement	Agree (1)	Neutral (2)	Disagree (2)	Mean	Standard deviation	Interpretation
1	Automating cataloging and bibliographic description using AI tools reduces human errors and accelerates access to resources.	41	13	4	2.64	0.61	High agreement
2	Enhancing search accuracy and information retrieval through systems based on neural ranking models and semantic query understanding.	40	18	0	2.69	0.46	High agreement
3	Enabling instant translation and automatic summarization of documents, facilitating understanding in multiple languages and saving researchers time.	45	13	0	2.78	0.42	High agreement
4	Providing intelligent chat-bots, offering instant support to users, and helping them navigate digital library services.	45	13	0	2.78	0.42	High agreement
5	Personalizing recommendations based on users' behavior and interests enhances their interaction with resources.	27	27	4	2.40	0.61	Neutral
6	Detecting plagiarism accurately and quickly using machine-learning algorithms and advanced text-matching techniques, safeguarding academic integrity.	54	4	0	2.93	0.25	High agreement
7	Analyzing user behavior via tools like Google Analytics to improve interface design and make data-driven service decisions.	36	18	4	2.55	0.62	High agreement
8	Integrating virtual and augmented reality to provide innovative educational and interactive experiences within the library.	49	9	0	2.84	0.36	High agreement
9	Archiving government documents and manuscripts using image recognition and AI techniques to preserve digital heritage.	40	13	5	2.60	0.64	High agreement

No.	Statement	Agree (1)	Neutral (2)	Disagree (2)	Mean	Standard deviation	Interpretation
10	Ensuring security and control of digital rights (DRM) by integrating AI with blockchain technologies to prevent unauthorized access.	36	18	4	2.55	0.62	High agreement

Table 2.
Mean scores and standard deviations of respondents’ perspectives on the effectiveness of artificial intelligence applications in digital libraries.

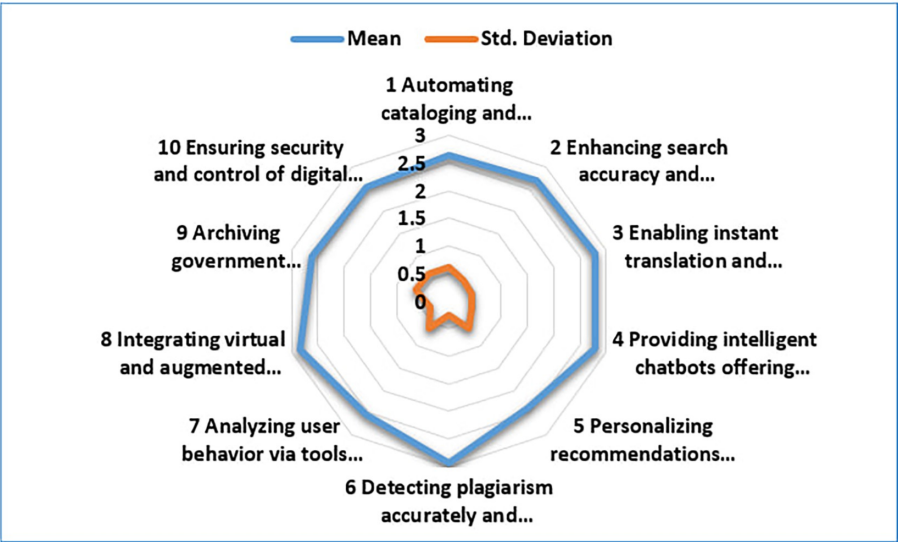


Figure 3.
Mean scores and standard deviations of respondents’ perspectives on the effectiveness of artificial intelligence applications in digital libraries.

enhancing the efficiency and quality of digital library services. This is further illustrated in **Figure 3**.

8.3 Ethical challenges associated with AI in digital libraries

Table 3 reveals a noticeable variation in respondents’ opinions. Most responses were neutral toward the majority of the ethical issues raised, such as algorithmic opacity, algorithmic bias, covert tracking of user behavior, and excessive reliance on intelligent systems. This neutrality suggests a growing awareness of ethical concerns, yet without the formation of definitive stances. Nonetheless, high levels of agreement emerged regarding key concerns, including the potential violation of privacy (Mean = 2.78), the impact of AI on user autonomy (Mean = 2.62), and the absence of legal frameworks (Mean = 2.53). These findings reflect a significant

No.	Statement	Agree (3)	Neutral (2)	Disagree (1)	Mean	Standard deviation	Interpretation
1	Lack of transparency in AI algorithms makes it difficult, at times, to understand how intelligent systems make their decisions.	23	31	4	233	0.60	Neutral
2	Intelligent systems exhibit algorithmic bias based on unbalanced or unfair training data.	27	22	9	231	032	Neutral
3	Privacy violations resulting from the collection and analysis of user data without explicit consent pose a significant ethical risk.	49	5	4	238	036	High agreement
4	Invisible surveillance by tracking user behavior in the digital library without their knowledge raises ethical concerns.	18	22	18	2.00	039	Neutral
5	Full reliance on intelligent systems may lead to marginalization of librarians' roles and expertise.	40	5	13	2.47	023	Neutral
6	The absence of legal and regulatory frameworks governing AI use in libraries may lead to potential violations.	40	9	9	233	0.75	High agreement
7	Exploiting data for commercial purposes and the possibility of sharing user data with third parties without their knowledge or consent.	36	4	18	231	0.91	Neutral
8	Intelligent systems may mislead users by recommending inaccurate or questionable sources.	23	22	13	2.17	037	Neutral
9	Lack of human oversight and allowing systems to operate autonomously may lead to errors or unethical decisions.	31	18	9	238	034	Neutral
10	The impact of AI on user autonomy and the excessive reliance on machines in decision-making regarding their choices.	40	14	4	2.62	0.61	High agreement

Table 3.
Analysis of respondents' opinions on the ethical challenges of using artificial intelligence in digital libraries.

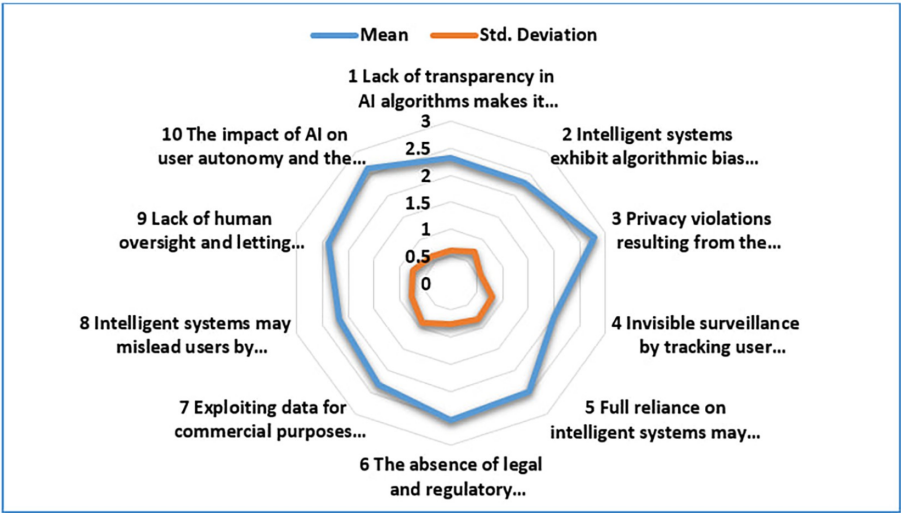


Figure 4. Mean scores and standard deviations of respondents' perspectives on ethical concerns related to artificial intelligence in digital library environments.

degree of apprehension among participants about the uncontrolled use of AI in libraries. The variation in means and standard deviations further highlights differing levels of awareness and perception among individuals, indicating the urgent need for user education and the development of clearer ethical and regulatory policies to ensure the safe and responsible deployment of these technologies. **Figure 4** illustrates these findings.

8.4 Privacy concerns and data protection

Table 4 indicates that the majority of respondents expressed a high level of agreement with the statements emphasizing the need to protect user privacy in the digital library environment, particularly statements (1, 4, 5, 6, 7, and 8), where the mean scores ranged from 2.69 to 3.00. This reflects a strong awareness of the importance of obtaining explicit consent, ensuring transparency, and providing user control tools. In contrast, statements (2, 3, 9, and 10) exhibited a neutral position, with average scores ranging from 2.23 to 2.27 and a relatively high standard deviation (0.87 to 0.94), which indicates a variation of opinions concerning users' discomfort or the sufficiency of existing privacy protection policies. It is important to note that a similar response pattern was noted for statements (3, 9, and 10), implying the necessity to reassess these items to confirm their accuracy or to detect potential duplication within the questionnaire. In summary, the results highlight the pressing requirement to establish clear and transparent policies for safeguarding users' data in digital libraries, especially considering the growing implementation of AI in providing information services. **Figure 5** illustrates these findings.

No.	Statement	Agree (3)	Neutral (2)	Disagree (1)	Mean	Standard deviation	Interpretation
1	Users are concerned about the collection of personal data in the digital library environment.	40	18	0	2.69	0.49	High agreement
2	I feel uncomfortable with the tracking of my search behavior by AI systems in the digital library.	27	18	13	2.23	0.87	
3	The lack of transparency in digital privacy policies undermines users' trust in library services.	27	22	9	2.27	0.94	
4	Digital libraries should seek explicit user consent before collecting or analyzing data.	45	13	0	2.78	0.49	High agreement
5	It is essential to have privacy protection policies for digital libraries and their users.	58	0	0	3.00	0.05	High agreement
6	It is important to provide user interfaces that allow reviewing or deleting stored data.	49	9	0	2.85	0.35	High agreement
7	AI is often used without clear communication to users about how their data is utilized.	40	18	0	2.69	0.66	High agreement
8	There is a need for policies to protect the privacy of digital libraries and their users.	49	9	0	2.85	0.35	High agreement
9	Smart applications in libraries may violate individual privacy if not properly regulated.	27	22	9	2.27	0.94	Neutral
10	Digital libraries use effective methods to protect user data when utilizing AI tools.	27	22	9	2.27	0.94	Neutral

Table 4.
Analysis of respondents' opinions on privacy and data protection concerns in digital libraries.

9. Conclusion

According to the study's findings, AI emerges as a promising tool for improving services in digital libraries. However, a host of ethical challenges and privacy concerns associated with its use must be considered. The findings indicate a growing awareness among faculty members in Iraqi IT and knowledge departments of the importance of using these technologies, despite ongoing concerns about transparency, algorithmic bias, and personal data protection. Accordingly, the study recommends establishing clear regulatory frameworks within academic institutions and libraries to regulate the use of AI tools and ensure their alignment with ethical

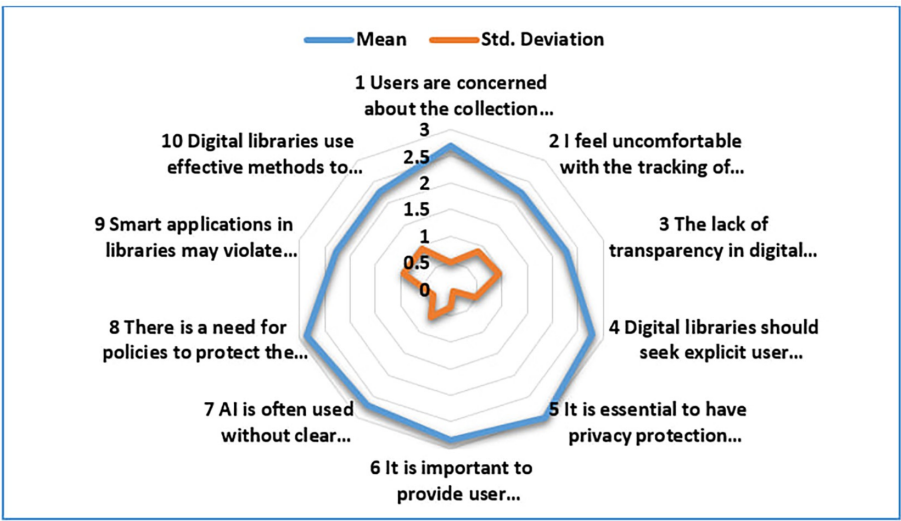


Figure 5.
Mean scores and standard deviations of respondents' perspectives on privacy and data protection concerns in digital libraries.

values. It also highlights the need for ongoing training programs for library staff to enhance their competencies in using these tools in a safe and responsible manner. Furthermore, the study emphasizes the importance of raising public awareness of the risks of privacy violations and promoting a culture of conscious and ethical use of smart technologies. Iraqi libraries are encouraged to benefit from leading international experiences in this field, particularly those that have successfully achieved a balance between technological advancement and the protection of user rights, ultimately contributing to the establishment of a safe, fair, and trust-based digital environment.

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Chapter 2

Bridging the Divide: AI-Driven Medical Data and Privacy in the Digital Library Landscape

Myongho Yi

Abstract

The integration of Artificial Intelligence (AI) in healthcare is transforming medical data management and utilization, with digital libraries as major research infrastructures for these vast datasets. This chapter, “Bridging the Divide: AI-Driven Medical Data and Privacy in the Digital Library Landscape,” examines the interplay between AI, medical data, and privacy within modern digital libraries. While AI enhances accessibility and analytical power of medical data, offering significant opportunities for diagnostics, treatment, and research, it also introduces substantial privacy concerns and ethical dilemmas. The chapter navigates these complexities, exploring responsible AI integration, data governance, anonymization, secure storage, and ethical frameworks to ensure medical advancements do not compromise individual privacy. It aims to foster a future where AI’s transformative potential and medical data sanctity coexist harmoniously within evolving digital libraries, benefiting science and society.

Keywords: artificial intelligence (AI), medical data, privacy, digital libraries, healthcare ethics

1. Introduction

The accelerating integration of Artificial Intelligence (AI) into the healthcare domain is ushering in an era of unprecedented transformation, particularly in how medical data is generated, managed, and utilized. At the heart of this revolution, digital libraries are rapidly evolving into sophisticated research infrastructures, tasked with housing and providing access to vast and sensitive repositories of medical information. This pivotal role places them directly at the nexus of immense opportunity and significant ethical challenges. While AI offers powerful capabilities to enhance the accessibility, discoverability, and analytical power of medical data—promising breakthroughs in diagnostics, treatment planning, and biomedical research—it simultaneously introduces substantial privacy concerns and complex ethical dilemmas, particularly concerning personal health information (PHI). The widespread adoption of Electronic Health Records (EHRs), for example, while modernizing healthcare, also brings inherent privacy and security considerations that demand careful navigation.

This chapter, “Bridging the Divide: AI-Driven Medical Data and Privacy in the Digital Library Landscape,” confronts this critical interplay. It delves into the intricate challenges and profound opportunities arising from the convergence of AI and medical data within the unique context of modern digital libraries. As these digital repositories expand, the potential for AI to sift through extensive datasets, identify imperceptible patterns, and accelerate medical innovation is immense. However, this progress must not come at the expense of individual privacy or data integrity.

To address these multifaceted issues, this chapter will explore several key aspects:

- The significant privacy vulnerabilities associated with EHRs, including risks of unauthorized access and data breaches, both external and internal.
- The crucial challenges of maintaining data quality—encompassing completeness, accuracy, timeliness, and consistency—which is paramount for the effective and ethical use of health data in AI applications.
- Strategies for the responsible integration of AI technologies within digital library ecosystems that manage medical data.
- Best practices for robust data governance, effective anonymization techniques, and secure data storage solutions.
- The necessary ethical frameworks required to ensure that AI-driven medical advancements uphold, rather than compromise, individual privacy.
- The symbiotic evolution of AI and libraries, considering how AI can transform library services while also presenting new ethical considerations that library professionals must navigate.

Ultimately, this chapter seeks to illuminate pathways towards “bridging the divide.” It aims to foster a future where the transformative potential of AI and the sanctity of personal medical data can harmoniously coexist within the evolving landscape of digital libraries, thereby benefiting both medical science and society at large. The goal is to ensure that as we harness AI for medical discovery, we do so with a steadfast commitment to ethical principles and the protection of individual rights.

2. Key challenges and transformations in AI-driven health data management within digital libraries

2.1 Safeguarding digital health: Navigating privacy issues in electronic health records

The digital transformation of healthcare through the adoption of Electronic Health Records (EHRs) has marked a significant step forward in enhancing patient care, operational efficiency, and medical research. However, this transition from paper-based systems to digital platforms brings to the forefront substantial challenges concerning the privacy and security of sensitive patient information. As healthcare organizations increasingly rely on EHRs, the imperative to protect patient confidentiality against a backdrop of evolving technological landscapes and potential threats

becomes paramount. Addressing these privacy issues is not merely a technical hurdle but a foundational requirement for maintaining patient trust and ensuring the ethical use of health data.

One of the most pressing concerns associated with EHRs is the heightened risk of unauthorized access and data breaches. Electronic records, by their nature, can be more vulnerable than their physical counterparts if not protected by robust security measures. The digital storage and transmission of health information expose it to a variety of external threats, including hacking attempts, malware infections, and sophisticated phishing schemes. The consequences of such security incidents can be severe, potentially leading to the widespread exposure of personal health information, which in turn can result in identity theft, financial repercussions, and significant personal distress for affected individuals. A systematic understanding of EHR security and privacy aspects is crucial for developing comprehensive strategies to mitigate these pervasive risks [1].

Beyond external threats, privacy vulnerabilities also exist within healthcare organizations themselves. Even with access controls and audit trails in place, the internal handling of patient data can pose risks. There is the potential for inappropriate access to patient records by authorized personnel for reasons not directly related to patient care, or inadvertent disclosures stemming from human error or insufficient staff training on privacy protocols. The challenges associated with implementing national EHR systems, for example, highlight the critical need to address key security and privacy issues to prevent internal misuse and ensure data integrity [2]. Moreover, it is vital to adopt an equitable approach when enhancing the privacy of consumer health information within large-scale systems, ensuring that all patient data is handled with consistent and fair protection measures [3].

The drive towards greater interoperability in healthcare, while aimed at improving care coordination and data exchange between different providers and systems, inadvertently introduces additional layers of privacy concerns. As EHRs become more interconnected and patient data flows across various platforms, the number of potential access points increases, thereby expanding the attack surface for data breaches or unauthorized use. This necessitates the implementation of standardized security protocols, robust data-sharing agreements, and comprehensive frameworks that prioritize patient privacy across disparate systems. The complexity of maintaining the privacy of electronic health records across such interconnected environments has been a significant focus of research, underscoring the multifaceted nature of this challenge [4]. These data protection issues are not unique to any single region, with various countries facing their own specific contexts and challenges in safeguarding EHR data [5].

The rapid evolution and integration of emerging technologies in healthcare, such as mobile health (mHealth), telemedicine, and cloud computing, further compound the privacy challenges associated with EHRs. Mobile health applications, which often collect, transmit, and store personal health information, can introduce new vulnerabilities, particularly if patient data is handled on personal devices or transmitted over insecure networks [6]. Telemedicine platforms, while offering remote access to care, also require careful consideration of security and privacy to protect patient consultations and associated data [7]. The broader context of pervasive healthcare systems, where technology is ubiquitously integrated into healthcare delivery, demands robust approaches to ensure both privacy and security [8]. Similarly, the storage and processing of health data in cloud environments necessitate a clear understanding of privacy requirements and feasibility analyses to implement effective safeguards [9].

Even innovative technologies like blockchain, which are explored for their potential to enhance security, come with their own specific set of security and privacy considerations that must be thoroughly evaluated in the healthcare context [10].

Addressing the spectrum of privacy issues in EHRs requires a comprehensive and multilayered strategy. Technologically, this includes the deployment of strong encryption mechanisms for data at rest and in transit, robust multifactor authentication for access control, and regular, thorough security audits to identify and remediate vulnerabilities. Organizational measures are equally crucial, encompassing the development and enforcement of clear and stringent policies regarding data access, appropriate use, and disclosure. Comprehensive and ongoing training programs for all healthcare personnel are essential to foster a culture of privacy awareness and ensure adherence to established protocols. Furthermore, patients should be empowered with transparent information about how their health data is being used, managed, and protected, along with mechanisms to exercise control over their information where appropriate. The literature suggests that effective EHR security and privacy necessitates such a holistic approach, combining technical safeguards with strong governance [1, 4].

In summary, while the adoption of Electronic Health Records offers transformative benefits to healthcare, the associated privacy challenges are significant and demand continuous attention. Ensuring the confidentiality, integrity, and availability of patient data in an increasingly digital and interconnected world requires a proactive, adaptive, and comprehensive approach. By integrating robust technological solutions, sound organizational policies, and a commitment to ethical data stewardship, healthcare providers can work towards harnessing the full potential of EHRs while upholding the fundamental right to privacy for every patient. The ongoing research and development in areas like secure mHealth systems, privacy in telemedicine, and trustworthy e-health cloud solutions reflect the critical importance of this endeavor for the future of healthcare [6, 7, 9].

2.2 Navigating the labyrinth: Addressing data quality challenges in health data

While Electronic Health Records (EHRs) are integral to modern healthcare, offering pathways to improved patient care, streamlined workflows, and facilitated research, their full potential is often hampered by issues related to data quality. Poor data quality can lead to a cascade of negative consequences, including compromised patient safety, flawed clinical decision-making, inefficient healthcare operations, and unreliable research outcomes. Addressing these challenges is crucial for leveraging EHR data effectively.

One of the primary concerns in EHR data quality is completeness. Missing data, whether it is patient demographics, clinical findings, or treatment information, can significantly impact the reliability of the record for both clinical care and secondary uses like research. For instance, incomplete medication lists can lead to adverse drug events, while missing lab results might delay diagnoses. Razzaghi et al. emphasize the importance of systematic data quality assessment to evaluate study-specific fitness, highlighting that completeness is a key dimension in this process [11]. Similarly, studies focusing on specific conditions like heart failure have underscored the challenges in achieving complete datasets based on international standards.

Accuracy is another critical dimension of EHR data quality. Inaccurate data can stem from various sources, including typographical errors during data entry, misinterpretation of clinical information, or incorrect coding. Wassell et al. explored clinician perspectives on EHR data quality for reuse in predictive modeling, revealing

that concerns about accuracy are prevalent among healthcare professionals [12]. Inaccurate information, such as incorrect allergy information or erroneous diagnostic codes, can directly endanger patients and lead to inappropriate treatment plans. Chen and Ren propose an EHR data quality evaluation approach based on medical knowledge and text matching, aiming to identify and mitigate such inaccuracies [13].

Timeliness of data entry also plays a significant role. Delays in recording patient encounters, test results, or changes in patient status can render the EHR less useful for real-time clinical decision-making and public health surveillance. Deady et al. analyzed data quality and timeliness for postvaccination adverse event reporting, demonstrating the critical need for prompt data capture in public health contexts [14]. If information is not entered in a timely manner, clinicians may be working with outdated information, potentially leading to suboptimal care.

Furthermore, consistency and comparability of data across different EHR systems and healthcare providers remain significant challenges. Lack of standardized terminologies, coding practices, and data formats can make it difficult to aggregate and compare data from various sources. Sidky et al. discussed data quality considerations when using real-world data for evaluating COVID-19 treatments, highlighting the complexities arising from data heterogeneity [15]. Efforts to automate data quality rules using standardized frameworks like openEHR archetypes aim to address these consistency issues.

The intended use of EHR data also influences the perception and requirements of data quality. Data that might be adequate for routine clinical care may not be sufficient for research purposes or for training predictive models, which often require higher levels of granularity and completeness. Razzaghi et al. advocate for developing a systematic approach to assessing data quality based on the intended use, acknowledging that different applications will have varying quality thresholds [16].

Addressing data quality issues in EHRs requires a multifaceted approach. This includes implementing robust data governance policies, providing ongoing training for staff on data entry best practices, utilizing data validation tools at the point of entry, and conducting regular data quality audits. Fu et al. explored methods for optimizing the efficiency and effectiveness of data quality assurance in multicenter clinical datasets, suggesting that systematic approaches are vital [17]. Moreover, fostering a culture of data quality awareness among all healthcare professionals is paramount. As highlighted by Gehrmann and Beyan in an oncological use case, understanding the nuances of data quality in medical real-world data is essential for its effective application [18].

The proliferation of health data, largely driven by the widespread adoption of Electronic Health Records (EHRs) and other digital health technologies, holds immense promise for revolutionizing healthcare delivery, research, and public health initiatives. However, the value of this data is intrinsically linked to its quality. Poor data quality can lead to flawed clinical decision-making, inaccurate research findings, and inefficient healthcare operations. This paper will explore the multifaceted issues surrounding data quality in health data, drawing upon recent literature to highlight common challenges and their implications.

The concept of data quality in the healthcare context is complex, encompassing various dimensions such as completeness, accuracy, consistency, timeliness, and correctness. Issues in any of these dimensions can significantly undermine the utility of health data. For instance, incomplete data in Electronic Medical Records (EMRs) can hinder a comprehensive understanding of a patient's health status, potentially leading to suboptimal treatment decisions. In a study investigating data completeness in a

tertiary hospital in Rwanda, Uwase et al. highlighted the challenges and the imperative need for improving data quality in EMRs [19].

A significant challenge lies in the inherent complexity and heterogeneity of health data itself. Health information is often recorded by various individuals across different systems and departments, leading to inconsistencies and a lack of standardization. Sarafidis et al. identified data quality challenges within a learning health system, emphasizing the difficulties posed by this diverse data landscape [20]. Furthermore, the Medical Informatics Initiative in Germany is actively working towards harmonized data quality, acknowledging the current fragmentation and outlining future directions to address this. The process of mapping data from different formats, such as HL7 v2 to openEHR, also presents considerable challenges and offers valuable lessons, as detailed by Anywar et al. [21].

The reuse of clinical data for secondary purposes, such as predictive modeling and research, further amplifies the importance of data quality. Wassell et al. explored clinicians' perspectives on EHR data quality for its reuse in predictive modeling, underscoring the need for data to be fit for such advanced analytical purposes [12]. If the underlying data is flawed, the resultant predictive models or research conclusions are likely to be unreliable. This is particularly critical in areas like oncology, where real-world data is increasingly used, and its quality is paramount for generating meaningful insights. Gehrman and Beyan specifically addressed data quality in medical real-world data using an oncological use case [18].

Contradictions within interdependent health data items serve as a key indicator of data quality issues. Yusuf et al. piloted the use of such contradictions to assess the impact of clinical study implementation on data quality assessments and also worked towards a consistent representation of these contradictions for more efficient data quality checks [22]. Similarly, the comparison of administrative medical data with billing data has been proposed as a method to improve health data quality, by identifying discrepancies and areas for improvement.

Ensuring data quality is not merely a technical challenge; it also involves organizational and human factors. The implementation of clinical studies, for example, can itself impact data quality, necessitating careful assessment and management. Moreover, the accessibility and maintenance of medical data archives, especially in low and middle-income countries, pose significant hurdles, often obscuring true public health statistics and measures. Abdul-Rahman et al. shed light on this "mystery" behind public health statistics due to inaccessible and poorly maintained medical data [23].

The development of integrated data quality management systems is a crucial step towards addressing these challenges. Oh et al. described the development of such a system for the Observational Medical Outcomes Partnership (OMOP) Common Data Model, a standardized data model used in many research networks [24]. Furthermore, tools and frameworks for assessing the quality and trustworthiness of biomedical datasets are emerging, such as the Venus score proposed by Chicco et al. [25]. Even in specialized areas like state registry reports of medical cannabis patients, data quality remains a concern that needs systematic attention. Boehnke et al. highlighted these data quality issues in US state registries [26]. The foundational role of clinical informatics in ensuring data quality, linkage, and access for sentinel and genomic surveillance over decades further emphasizes the long-standing importance of this issue.

The quality of data is a cornerstone for developing robust, effective, and ethical Artificial Intelligence (AI) models, particularly in critical domains such as healthcare.

The adage “garbage in, garbage out” is especially pertinent to AI, as the model’s learning process and subsequent performance are intrinsically tied to the characteristics of the training data. Deficiencies in data quality can lead to suboptimal model performance, introduce and amplify biases, and ultimately undermine the reliability and trustworthiness of AI-driven insights and decisions. Several dimensions of data quality directly influence these aspects. Systematic data quality assessment is crucial to evaluate if data are fit for their intended use in AI applications [11, 16]. The various facets of data quality each bear a distinct influence on these AI characteristics. Consistency of data, meaning uniformity and the absence of contradictions across various data sources, systems, or overtime, is also crucial. Inconsistent data, such as the use of disparate units for the same variable or conflicting information for a single patient, can perplex AI models. This confusion makes it difficult for models to discern coherent patterns, leading to suboptimal predictive performance. The challenge of maintaining consistency is particularly acute when integrating data from multiple sources, a common requirement in healthcare AI [21]. Should these inconsistencies disproportionately affect specific records or demographic groups, the model training process can become skewed, resulting in biased outcomes. AI models developed using inconsistent data are prone to producing erratic and unreliable outputs because the foundational information lacks internal coherence, underscoring the importance of establishing data consistency for building trustworthy AI [8]. Validity, along with the related concepts of plausibility and conformance, ensures that data adhere to predefined business rules, formats, ranges, or constraints—for example, age must be a positive integer, or specific medical codes must align with a valid lexicon [9]. Invalid data can precipitate technical failures during model training or mislead the model into learning incorrect relationships, thereby impairing its performance. The evaluation of data for conformance to established standards is a critical step in maintaining data quality [9]. If data validation protocols are not applied consistently, or if certain groups are more susceptible to having data that fails validation (perhaps due to systemic issues in data collection processes), these groups may become under-represented or misrepresented in the training dataset, introducing bias. Models exposed to invalid or implausible data may behave unpredictably, diminishing their overall reliability and the confidence that can be vested in their outputs. Confronting these multifaceted data quality dimensions extends beyond mere technical necessity; it is an ethical imperative, particularly when AI models are poised to influence critical decisions in arenas such as healthcare. As emphasized by Wassell et al., a thorough understanding of EHR data quality as perceived by clinicians is vital for its effective reuse in predictive modeling, and there remains a tangible risk of models developing demographic biases if data quality deficiencies are not meticulously addressed [3, 12]. Deficient data quality, encompassing prevalent issues like missing values and inconsistencies, is a widely acknowledged challenge within EHR data [9]. Such deficiencies can contribute to the development of biased AI models that risk perpetuating existing healthcare disparities [9]. Consequently, the implementation of rigorous data quality assessment, diligent management, and continuous improvement strategies is of paramount importance to responsibly and equitably unlock the transformative potential of AI [15, 18, 24].

In summary, data quality issues in health data are pervasive and multifaceted, stemming from data complexity, diverse recording practices, and challenges in management and reuse. Improving health data quality is not merely a technical task but a fundamental requirement for advancing patient care, fostering reliable research, building effective public health systems, and developing trustworthy AI. Concerted

efforts involving technological solutions, standardization, robust data governance, and a culture of quality consciousness among all stakeholders, alongside ongoing developments in harmonized approaches and assessment tools, are critical to navigating this labyrinth and unlocking the true potential of health data.

2.3 The symbiotic evolution: AI and the transformation of libraries

The rapid advancement of Artificial Intelligence (AI) is instigating transformative shifts across numerous sectors, and libraries, both traditional and digital, are no exception. The integration of AI technologies promises to redefine library services, operations, and the very role of libraries as hubs of information and knowledge. From enhancing user experience through personalized recommendations to streamlining complex tasks like cataloging and research support, AI is poised to become an indispensable partner in the evolution of library and information science. This chapter explores the multifaceted impact of AI on libraries, drawing upon recent scholarly contributions to understand current applications, address emerging challenges, and consider the future trajectory of this symbiotic relationship.

The application of AI in libraries is diverse and expanding, touching nearly every facet of library operations and user engagement. One significant area is the optimization of digital library services. For instance, AI can be leveraged to improve search algorithms, making it easier for users to discover relevant resources within vast digital collections [27]. This is particularly crucial as libraries increasingly become digital research infrastructures, requiring sophisticated tools to manage and provide access to complex datasets and digital-born materials [28]. National libraries, like the National Library of Sweden, are actively involved in creating and utilizing AI models, such as BERT, to enhance their digital services and support new forms of research [29]. Furthermore, generative AI is being explored for its potential in tasks like summarizing texts and even assisting in content creation, although this also raises important considerations regarding academic integrity [30]. AI-driven tools can also enhance information literacy programs, providing personalized support to users as they navigate the increasingly complex information landscape [31]. The development of AI competences within library staff is also a growing area of focus, ensuring that librarians are equipped to manage and leverage these new technologies effectively [32].

The integration of AI into digital library systems is also being advanced through the use of knowledge graphs. These sophisticated data structures can help to organize and connect information in more meaningful ways, moving beyond keyword-based search to a more contextual and relational understanding of library resources [33]. This can lead to more intuitive discovery experiences and facilitate new avenues for research and learning. In Southeast Asia, for example, there is a growing interest in reviewing and implementing various AI applications to enhance library services, indicating a regional trend towards embracing these technologies [34]. The evolution of library automation systems, historically a cornerstone of library technology, continues with AI, promising more intelligent and efficient management of library resources and workflows [35]. Libraries are also seen as having a crucial role in promoting algorithmic literacy, helping users understand how AI systems work and the implications of their use [36].

However, the integration of AI in libraries is not without its challenges and ethical considerations. The “wild west” nature of generative AI necessitates careful consideration of how to integrate these tools responsibly [33]. Issues such as data privacy,

particularly with the use of public AI chatbots, are paramount, and librarians are key stakeholders in safeguarding user information and ensuring ethical AI deployment [37]. The potential for bias in AI algorithms, often trained on large datasets, is another significant concern that libraries must address to ensure equitable access and representation [38]. Academic libraries, in particular, are grappling with the implications of AI on academic integrity and are developing policies and strategies to navigate these complexities [30, 39]. Furthermore, leadership styles within libraries can significantly impact the acceptance and successful implementation of AI technologies, highlighting the need for proactive and informed leadership [40]. Evaluating the ethical implications of AI through foresight analysis can help identify potential problems before they arise, allowing libraries to develop proactive strategies [41].

Looking ahead, the future of library and information science will undoubtedly be intertwined with AI [42]. Experimentation-driven frameworks are being proposed to help libraries leverage AI technologies effectively, encouraging innovation and adaptation [43]. The development of emerging technologies and the requisite skills to utilize them will be crucial for improving service delivery in digital libraries [44]. As AI continues to evolve, libraries will play a vital role not only in adopting these technologies but also in shaping their ethical development and application, ensuring that AI serves to enhance, rather than diminish, the core values of access, equity, and intellectual freedom that define the library institution [45, 46].

In summary, AI presents both immense opportunities and significant challenges for libraries. From optimizing digital services and enhancing research support to fostering algorithmic literacy, AI technologies are reshaping the library landscape. The successful integration of AI requires careful planning, ethical consideration, and a commitment to developing the necessary skills and frameworks. As libraries continue to evolve as digital research infrastructures and vital community resources, their engagement with AI will be critical in defining their future relevance and impact in an increasingly technology-driven world. By proactively embracing innovation while thoughtfully addressing the associated ethical dimensions, libraries can harness the power of AI to better serve their communities and advance the frontiers of knowledge.

3. Conclusion

As healthcare navigates its digital evolution, profoundly shaped by Electronic Health Records (EHRs) and the increasing impact of Artificial Intelligence (AI), the prospects for advancing patient care, medical research, and operational effectiveness are considerable. However, this progress is inextricably linked to profound responsibilities, primarily the unwavering protection of patient privacy and the steadfast assurance of data quality. As we integrate these technologies, with digital libraries evolving into crucial infrastructures for managing and disseminating health information, a clear and ethically grounded path forward is essential.

The critical imperative of privacy in EHRs cannot be overstated. While digital records offer unparalleled benefits, they concurrently amplify risks of unauthorized access, data breaches, and misuse. External threats like hacking and phishing, alongside internal vulnerabilities stemming from human error or improper access, demand a robust, multi-layered defense. The drive for interoperability, essential for coordinated care, paradoxically expands the potential attack surface, necessitating standardized security protocols and comprehensive governance. Furthermore, emerging technologies such as mHealth, telemedicine, and cloud computing introduce new

complexities, compelling a proactive and adaptive security posture. The solution lies in a comprehensive strategy encompassing strong encryption, multifactor authentication, regular security audits, lucid organizational policies, thorough staff training, and the empowerment of patients through transparency and control over their data. Ultimately, preserving patient trust and upholding the ethical stewardship of sensitive health information hinges on this multifaceted commitment to confidentiality, integrity, and availability.

Parallel to privacy concerns, the utility and reliability of EHRs and AI-driven healthcare insights are fundamentally dependent on the quality of the underlying data. Deficiencies in data—whether in completeness, accuracy, timeliness, or consistency—can precipitate severe consequences, including compromised patient safety, flawed clinical decisions, inefficient healthcare operations, and unreliable research outcomes. Incomplete records can stymie both clinical care and research, while inaccuracies can directly endanger patients. Delayed data entry can lead to decisions based on outdated information, and a lack of standardization across systems impedes data aggregation and comparative analysis, crucial for learning health systems and multi-center research. Recognizing that different applications, such as research versus routine care, may have varying data quality requirements, a robust approach is needed. This involves strong data governance, continuous staff education, sophisticated data validation tools, regular audits, and fostering a pervasive culture of data quality awareness among all healthcare professionals. Investing in integrated data quality management systems is paramount to unlocking the true potential of health data.

Simultaneously, the rapid advancement of AI is instigating a paradigm shift within libraries, reshaping their services, operational frameworks, and their very identity as information hubs. AI promises to personalize user experiences, streamline complex tasks such as cataloging and research support, and significantly improve the discoverability of resources within vast digital collections. National libraries are already pioneering AI applications to augment digital services and support novel research methodologies. While generative AI offers exciting possibilities for content creation and summarization, and AI-driven tools can bolster information literacy, their integration demands careful ethical consideration. Challenges such as data privacy with public AI tools, potential algorithmic bias, and implications for academic integrity require proactive development of policies and ethical frameworks. Effective leadership and vigilant ethical foresight are indispensable for the responsible and beneficial adoption of AI in these vital institutions.

In charting the path forward, the convergence of AI, medical data, and digital libraries signifies a landscape of immense opportunity intricately woven with significant challenges. The potential for AI to revolutionize healthcare—enhancing diagnostics, optimizing treatment plans, accelerating research, and democratizing access to medical knowledge—is extraordinary. Digital libraries are positioned to become critical enablers in this new era, serving as trusted infrastructures for managing and providing access to sensitive health information. However, realizing this potential responsibly mandates an unwavering commitment to addressing the intertwined issues of privacy and data quality.

Looking ahead, the trajectory of AI-driven medical data management within digital libraries points towards several key future prospectives. We anticipate the proliferation of more sophisticated AI models capable of unlocking deeper insights from complex health datasets, potentially revolutionizing personalized medicine, predictive diagnostics, and therapeutic development. Concurrently, the role of digital libraries is expected to evolve beyond mere repositories into active hubs for ethical AI

development, data stewardship, and the cultivation of advanced data and algorithmic literacy for both researchers and the public. Future advancements will likely see the wider adoption and refinement of privacy-enhancing technologies (PETs), building upon current needs for anonymization and secure storage, to enable more secure and ethical data sharing and collaborative research across institutions. The push towards greater interoperability and standardized data models, such as the Observational Health Data Standards (OMOP) Common Data Model, will continue, fostering more cohesive health data ecosystems. Furthermore, the development and implementation of robust, globally aware ethical governance frameworks for AI in healthcare will be critical. Empowering patients with greater transparency and control over their data will also be a defining feature of these future developments. This dynamic landscape will demand continuous learning, adaptation, and proactive engagement from all stakeholders to ensure that technological advancements translate into equitable and beneficial outcomes for society.

Therefore, bridging the divide between the transformative capabilities of AI in processing medical data and the fundamental right to privacy necessitates a holistic, collaborative, and adaptive strategy. This requires sustained dialog and concerted action from a diverse array of stakeholders, including healthcare providers, researchers, policymakers, technologists, and library professionals. By proactively confronting ethical, technical, and operational hurdles, and by cultivating a culture of responsibility and continuous improvement, we can harness the full power of AI and digital information ecosystems. This endeavor will not only propel medical science and enhance patient outcomes but also ensure that these powerful technologies serve humanity equitably and ethically. The sanctity of personal health information must be vigilantly safeguarded within the dynamic landscape of the twenty-first-century digital library, ensuring that innovation and fundamental human values advance in unison. This journey demands constant vigilance and an unyielding commitment to harmonizing progress with principle.

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Chapter 3

From E-books to Intelligent Content: Advancing Smart Book Development in Digital Libraries

Alipour Hafezi Mehdi

Abstract

This chapter explores the evolution of digital reading materials, from static electronic texts to context-aware adaptive publications that respond to individual user needs. It begins by tracing the history of e-books, highlighting key milestones in format standardization, distribution, and user interface design. It then introduces the concept of “smart books.” Through a detailed examination of semantic enrichment techniques, I demonstrate how machine-readable markup and linked data can transform simple text into intelligent content capable of suggesting related materials, summarizing complex passages, and supporting targeted searches. The chapter then surveys adaptive reading systems that customize layout, navigation, and content delivery based on reader behavior, device type, and accessibility needs. The case studies demonstrate implementations in academic and public digital libraries, showcasing improvements in engagement, understanding, and discoverability. Finally, I discuss technical challenges such as interoperability, metadata quality, and privacy concerns, and offer best practices for integrating smart book technologies into existing digital library platforms. Ending with a forward-looking perspective, the chapter highlights emerging trends and research directions that will shape the next generation of intelligent reading experiences.

Keywords: e-book, electronic book, intelligent content, smart book, digital library, smart library

1. Introduction

Books have long been a foundation of the intellectual and cultural progress of civilizations, preserving and sharing knowledge since the invention of writing. The development of bookmaking technologies – from inscribed materials to the codex and paper – greatly improved the accessibility and usefulness of written texts across different societies. The invention of the printing press in the fifteenth century by Johannes Gutenberg marked a pivotal moment, democratizing information and making books a central medium for education and cultural exchange. In the modern era, digital technologies have introduced a new chapter in the history of literature. Electronic books

(e-books) offer more than simple digital copies of printed texts; they deliver interactive, multimedia-rich experiences with unmatched flexibility for access and customization. Features like full-text search, portable libraries, and real-time updates have transformed the reading experience. Additionally, digital publishing significantly reduces production costs, thereby broadening access to literature worldwide. These changes highlight the enduring significance of books while showcasing their ongoing evolution in response to technological progress [1].

The evolution of e-books represents a pivotal advancement in information dissemination and reading practices, characterized by transformative milestones that have progressively integrated technology into literature consumption. In 1971, Michael Hart launched Project Gutenberg¹, initiating the digitization of texts with the Declaration of Independence as the inaugural entry, thereby establishing a foundational repository for free digital literature [2]. Throughout the 1990s and the 2000s, the advent of CD-ROM formats and online bookstore distribution models facilitated broader accessibility and commercial viability of electronic content, bridging traditional publishing with emerging digital infrastructures. The year 2007 marked a significant paradigm shift with the release of Amazon's Kindle and Apple's iPhone, which redefined mobile reading experiences through enhanced portability, user interfaces, and ecosystem integration, accelerating the mainstream adoption of e-books in educational and recreational contexts [3].

The transformation of books from print to digital formats and ultimately to intelligent content is fundamentally driven by evolving information-seeking behaviors and user needs in the communication age [4–7]. Initially, the shift from oral to print culture democratized access to knowledge through the mass production of books. The digital era has further enhanced accessibility, enabling rapid distribution, full-text search, personalization, multimedia integration, and cost efficiency. In the current phase, intelligent content powered by artificial intelligence (AI), augmented reality (AR), and virtual environments (virtual reality [VR]) offers interactive, multisensory, and user-tailored experiences. These technologies not only personalize reading and facilitate adaptive content creation but also introduce gamified narratives and immersive storytelling, reflecting a broader transition from passive knowledge consumption to dynamic user-centric engagement.

In recent years, information and communication technologies have experienced significant changes, most notably through the rise and spread of AI-based tools. This technological shift has greatly altered how people seek information, creating new ways for individuals to access, evaluate, and engage with information. In today's digital environments, the lack of virtual intelligent assistants is increasingly seen as a major gap, highlighting their crucial role in enabling efficient and meaningful interaction with information resources like academic literature. This chapter explores how digital reading materials have evolved from static texts to intelligent, context-aware publications. The rest of the chapter explains the concept of smart books, presents several case studies in this area, discusses technical challenges and successful examples, and considers the future growth of smart books, including emerging trends.

⁴⁶ <https://www.gutenberg.org/>

2. What should we know about “smart books”?

Building on the historical evolution of e-books outlined in Section 1, this section defines smart books as a transformative advancement, integrating AI, semantic technologies, and adaptive systems to create dynamic, user-centric reading experiences. It explores their core components through three key areas: their evolutionary context, semantic enrichment techniques, and adaptive personalization capabilities.

2.1 Evolution of smart books and semantic enrichment

Smart books represent a significant leap from traditional e-books by integrating advanced technologies to deliver dynamic, interactive, and personalized reading experiences. To contextualize their development, **Table 1** outlines the historical evolution of digital reading materials, highlighting key technological milestones and their impacts on digital libraries. This progression underpins the shift toward intelligent content, with semantic enrichment serving as a cornerstone for smart book functionality.

Semantic enrichment, a critical feature of smart books, involves embedding machine-readable metadata and annotations into content to enable intelligent processing. Technologies such as Resource Description Framework (RDF), Web Ontology Language (OWL), and Natural Language Processing (NLP) model key concepts and their relationships, transforming static text into dynamic knowledge graphs. For example, tools like WordNet and ConceptNet² use linked data to establish conceptual connections, enhancing semantic search and cross-document browsing. Future-oriented advancements in semantic enrichment include semi-automatic markup tools and ontology learning software (e.g., the SEKT project), which streamline metadata creation and infer relationships even for untagged content. These innovations enable smart books to anticipate user needs, such as suggesting related materials or summarizing complex passages in real-time, positioning digital libraries as adaptive, user-centric ecosystems.

Era	Key technologies	Impact on digital libraries
1970s–1980s	Project Gutenberg, early digitization	Established free digital text repositories, enabling global access to public domain works.
1990s–2000s	CD-ROM, online bookstores, PDF/EPUB formats	Facilitated commercial e-book distribution, integrating digital collections into libraries.
2007–2010s	Kindle, iPhone, e-reader apps, cloud storage	Enhanced mobile access, full-text search, and user interfaces boost library circulation.
2020s–Present	AI, NLP, semantic markup, adaptive systems	Enabled context-aware, personalized content delivery, improving discoverability and engagement.

Table 1.
Evolution of digital reading materials.

⁴⁷ <https://conceptnet.io/>

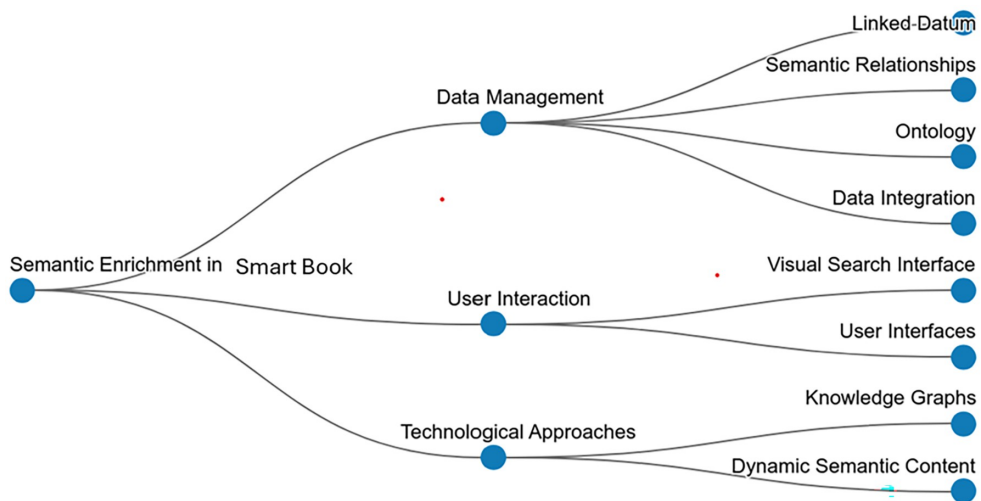


Figure 1.
Semantic enrichment in smart books.

2.2 Semantic enrichment techniques

Semantic enrichment enables smart books to transform static text into machine-readable, context-aware content. Using standards like RDF and OWL, smart books create knowledge graphs that model concepts and relationships, enhancing semantic search and browsing [4, 8]. Tools like WordNet and ConceptNet link related ideas, while NLP algorithms, such as Google’s BERT and Hummingbird, analyze contextual relationships to generate summaries or disambiguate queries [9, 10]. Projects like SEKT use ontology learning to automate metadata creation, integrating diverse schemas for efficient cataloging [4]. Platforms like Smart-logic and Ontotext further enhance discoverability by interlinking metadata with knowledge graphs, as illustrated in **Figure 1**. These techniques enable smart books to suggest related materials and support advanced content management in digital libraries [5].

Figure 1 depicts the semantic enrichment pipeline, illustrating how RDF/OWL annotations and NLP transform raw text into intelligent content. The diagram shows a flowchart with stages: text input, ontology-based tagging, knowledge graph construction, and output features like semantic search and real-time summaries. Arrows connect tools (e.g., WordNet, BERT) to their roles, with a sample knowledge graph highlighting linked concepts (e.g., “book” to “author” to “genre”).

2.3 Adaptive personalization

Smart books personalize reading by adapting content to user behavior, preferences, and device types. Embedded analytics track reading habits and performance, feeding machine learning (ML) algorithms to create tailored profiles that drive recommendations and adjust content difficulty [11, 12]. For example, the Smart Book Assistant uses NLP to suggest relevant resources, while multi-attribute collaborative filtering analyses borrowing histories to enhance discoverability [13]. Application Programming Interfaces (APIs) enable interactive features like quizzes,

multimedia, and real-time feedback, transforming reading into an engaging learning experience [5, 8]. Accessibility features ensure compatibility across devices, supporting diverse learning styles (e.g., visual or verbal) with dynamic cognitive scaffolding to improve comprehension and digital literacy [14, 15]. These capabilities make smart books responsive tools for education and engagement in digital libraries [7].

3. Case studies in smart book implementations

The integration of AI and advanced technologies is transforming library services, enabling smart books and intelligent frameworks that deliver personalized, efficient user experiences. These advancements move beyond traditional e-book formats, offering adaptive content and sophisticated management systems. This section presents three case studies – Europeana’s semantic enrichment, New York Public Library’s adaptive apps, and XYZ University’s adoption of smart shelves – detailing their context, implementation steps, and library-specific outcomes. Finally, in Sections 3 and 4, smart book assistance projects are discussed.

3.1 Europeana’s semantic enrichment with AI

Europeana³, a digital platform aggregating over 50 million cultural heritage items from more than 4,000 European institutions, has implemented AI-driven semantic enrichment to produce machine-readable, context-aware content in alignment with smart book principles. The EuropeanaTech AI in relation to Galleries, Libraries, Archives, and Museums (GLAMs) Task Force Report presents a comprehensive exploration of how AI is reshaping the cultural heritage sector, particularly within GLAMs. The report underscores a transformative shift toward dynamic, AI-enabled learning environments, where institutions are leveraging ML, NLP, computer vision, and semantic technologies to enrich digital collections and enhance user engagement. Through a sector-wide survey and in-depth interviews with professionals from leading European institutions, the Task Force reveals that AI is being used to automate metadata extraction, improve search and browsing functionalities, and generate new interpretive layers of cultural content. These innovations allow GLAMs to move beyond static repositories and become responsive, intelligent platforms for discovery and education. Projects cited in the report demonstrate how AI tools can identify patterns, classify images, and translate historical texts, making collections more accessible and contextually rich. However, the report also highlights challenges such as the need for annotated training data, ethical concerns around bias and deepfakes, and the integration of AI into legacy systems. Despite these hurdles, the findings affirm that AI holds immense potential to support personalized learning, semantic enrichment, and cross-disciplinary collaboration. Europeana’s leadership in this space exemplifies how cultural institutions can evolve into dynamic learning centers, fostering deeper public engagement and unlocking new dimensions of cultural understanding through intelligent technologies [8, 9].

⁴⁹ <https://pro.europeana.eu/>

3.2 New York Public Library’s AI-enhanced adaptive apps

The New York Public Library (NYPL), serving approximately 17 million patrons annually, embarked on a modernization effort to enhance digital access tailored to diverse user needs through participation in New York City’s AI Strategy. To achieve this, NYPL developed adaptive applications incorporating AI to deliver smart book recommendations and advanced search functionalities. The NYPL system, encompassing the New York, Brooklyn, and Queens branches, is undergoing a transformative shift toward becoming dynamic AI-enabled learning centers. As outlined in the NYC AI Advantage 2025 Report, these libraries are no longer just repositories of books but are evolving into hubs of digital empowerment and equitable access to emerging technologies. Central to this transformation is a city-backed initiative that trains librarians in AI fundamentals, equipping them to serve as educators and mentors within their communities. Through a “train-the-trainer” model, librarians gain proficiency in safe and responsible AI use, enabling them to guide patrons – particularly youth – in leveraging AI tools for academic support, career development, and digital literacy. These tools, integrated into library computer labs, offer intelligent assistance such as personalized learning pathways, AI-generated content summaries, and adaptive educational resources. While not explicitly branded as “smart books,” these AI-augmented services reflect the core principles of smart book ecosystems: responsive, personalized, and context-aware learning experiences. By embedding AI into everyday library services, the initiative fosters a new paradigm where libraries act as catalysts for lifelong learning and technological fluency. This approach not only democratizes access to AI but also positions public libraries as strategic platforms for community-based innovation. In doing so, New York’s public libraries exemplify how traditional institutions can be reimaged through AI to meet the evolving educational and informational needs of a diverse urban population, making them vital players in the city’s broader digital transformation [10, 11].

3.3 XYZ University the adoption of smart shelves

The XYZ University⁴ leverages Radio Frequency Identification (RFID) technology for significant operational improvements [12]. This case study demonstrates how RFID-enabled shelves can provide real-time information on book locations and availability, enhancing both security and user access. Post-implementation, the library witnessed a 40% reduction in inventory check time and a 30% decrease in lost books. User satisfaction soared, with 85% of patrons reporting ease in finding books due to the real-time access feature of the app. The system also generated valuable data analytics on library usage, guiding better shelf organization and resource allocation, and leading to improvements in accuracy (up to 95%), space utilization (up to 90%), precision (up to 93%), F1 Score (up to 93%), and Area Under the Curve (AUC) (up to 0.96) in various performance metrics [12].

4. Smart book assistant: AI-generated content and semantic integration

Beyond physical book management, smart library frameworks are increasingly employing AI-generated content (AIGC) in various forms to enhance their services.

⁵⁰ <https://www.xyzuniversity.com/>

The foundational Semantic Web concept, with its semantic metadata and Linked Open Data, makes content machine-interpretable, allowing for meaningful context and relationships between data. This is crucial for semantic search, as it enables systems to understand the user's intent and context rather than just keywords, leading to more precise content discovery. Technologies such as RDF, SPARQL, and OWL facilitate this deep semantic understanding. Examples include the "Smart Book Assistant," an AI-powered digital library leveraging NLP and ML for intelligent recommendations and real-time summaries [13], which falls under the umbrella of AIGC by providing AI-generated textual output.

Furthermore, smart library frameworks use AI not only for enhanced search but also for highly personalized content delivery and virtual reference services [5, 14]. Platforms like APPEAL utilize Deep Q-Network Reinforcement Learning (DQN-RL) for adaptive personalized content presentation (e.g., VARK modalities or gamification) and adaptive exercise navigation, tailoring the learning experience to individual student needs and learning styles [15]. Similarly, adaptive e-books employ AI algorithms to customize content and difficulty levels based on a reader's progress, offering intelligent content and customized book recommendations [16]. These AI-driven systems contribute to cognitive scaffolding and provide targeted support, effectively transforming static educational materials into dynamic and responsive learning environments [7].

In conclusion, ongoing case studies and the development of intelligent frameworks highlight a transformative shift in library and educational paradigms. From the operational efficiencies and enhanced user experiences delivered by RFID-enabled Smart Shelves at institutions like XYZ University to the conceptual roots of automated readers inspiring modern devices, and the advanced capabilities of AI in driving semantic search, content personalization, and AIGC-enabled services within smart libraries, technology is creating more responsive, efficient, and engaging environments for knowledge acquisition and dissemination [12, 13, 17, 18]. These implementations underscore AI's pivotal role in shaping the future of libraries and learning, fostering both operational excellence and a deeply customized user journey.

5. Technical challenges and best practices in the smart book industry

A fundamental aspect of smart books, as previously discussed, is their use of semantic markup, which makes the content machine-understandable through the addition of semantic metadata. This is achieved by employing ontologies, NLP, and data mining techniques to model key concepts and their relationships, facilitating a more efficient semantic search and improved browsing experience for users. A significant technical challenge for smart books, as presented in **Figure 2**, is interoperability across various formats (such as EPUB3, ONIX, and METS) and platforms. The existing landscape of e-books is fragmented, with numerous formats often proving incompatible and non-interoperable [19]. Moreover, different institutions, such as libraries, museums, and archives, tend to utilize diverse technologies and methodologies for managing their digital collections, complicating unified access [4]. To address this, the Semantic Web introduces key technologies such as RDF, SPARQL, and OWL, which establish a common framework for computer systems to create meaningful relationships among disparate data

Overcoming Technical Challenges in Smart Books



Figure 2.
Technical challenges in smart books.

resources. Best practices involve ontology merging and mapping to enable seamless access to distributed information [4]. Furthermore, e-learning standards such as SCORM, IMS, and IEEE-LOM are crucial for facilitating the interoperability of content across various educational platforms [6].

Another critical challenge is ensuring high-quality and consistent metadata through automated enrichment pipelines. Libraries often face difficulties in metadata quality due to issues with software, insufficient audit and control mechanisms, lack of trained staff, limited awareness of data management processes, and the absence of national standards [20]. Traditional library systems are typically restricted to basic storage and querying, which limits their capacity for advanced analyses and data mining [17]. To overcome this, ML algorithms can optimize database management and continuously expand the information content of specific collections [17]. Semantic metadata is vital as it provides meaning about the data itself, which helps resolve ambiguities in search queries and allows machines to comprehend content effectively. The integration of AI-assisted data modeling tools and automated metadata creation processes, aligned with Semantic Web standards, is the best practice to reduce costs and errors and enhance data harmonization for a superior user experience [4].

Addressing privacy concerns in reader data analytics is paramount and requires robust anonymization and consent mechanisms. AI-powered platforms inherently collect and analyze extensive user data, including reading habits and preferences, which raises significant privacy and data security issues, especially given the commercial value of user data in the current digital economy [16]. To mitigate these concerns, ethical safeguards must be integrated as core components of AI-driven educational strategies, ensuring that systems are transparent, accountable, and designed to promote equity [7]. Key best practices include designing AI algorithms to incorporate fairness and bias mitigation strategies, protecting users' privacy, and ensuring that AI-driven decisions are explainable and auditable [7]. Additionally, users must be given clear control over their data, defining what information is accessible and what remains "off-limits" [4], supported by the implementation of robust encryption protocols and restricted access to sensitive data [21].

Effectively addressing these technical challenges is crucial for realizing the full potential of smart books and the future of personalized learning [16]. When successfully implemented, these technologies lead to significant improvements in learning outcomes, increased reader engagement, enhanced comprehension, and better knowledge retention, ultimately fostering greater digital literacy [7, 22]. Smart books can provide users with tailored content, relevant recommendations, and interactive learning experiences that adapt to their individual needs [16]. Future endeavors should prioritize the continuous enhancement of AI algorithms, the development of comprehensive ethical frameworks, and further research into the long-term impacts of these platforms in diverse educational settings. Practical implementation strategies, including effective training for educators and overcoming potential resistance to technology adoption, will be essential to maximize the transformative impact of smart books on education [7, 16, 17, 22].

Despite the promising examples outlined in this section, the concept of smart books remains in its infancy. The intersection of books, AI, and cloud-powered big data analytics marks a pivotal moment in the evolution of the book industry. Thus, smart books, characterized by the integration of advanced technologies such as AI, Internet of Things (IoT), blockchain, cloud computing, and big data, aim to redefine user experiences and operational efficiency. A wide array of initiatives is currently being pursued, each employing a distinct methodology and framework. Given the diversity and experimental nature of these studies, it may be premature to draw definitive conclusions. Time is required for the field to evolve into a coherent procedural and conceptual foundation. Preliminary analyses suggest that these developments may soon give rise to a transformative phenomenon that could significantly reshape our understanding of the ontology and function of books.

6. Future directions and emerging trends of smart books

The evolution of smart books is poised to reshape digital libraries into dynamic, intelligent ecosystems that transcend current capabilities. While semantic enrichment and foundational AI technologies have laid the groundwork for context-aware content (see Section 2.1), future trends will leverage generative AI, advanced library infrastructure, immersive technologies, and decentralized systems to redefine how knowledge is created, consumed, and managed. This section explores speculative advancements that promise to enhance personalization, accessibility,

and engagement in digital libraries while addressing persistent challenges in adoption.

6.1 Next-generation AI for dynamic content creation

Artificial intelligence is set to revolutionize smart books by enabling dynamic, generative content tailored to individual users. Beyond current adaptive systems that adjust difficulty based on progress, future AI could create interactive narratives or cross-media summaries (e.g., text-to-video explanations) in real-time, driven by large language models (LLMs) and emotion-aware algorithms [11]. For instance, a smart book might detect reader confusion via eye-tracking data and generate a simplified explanation or an interactive quiz on the fly. Platforms like the Smart Book Assistant, which already use NLP for recommendations, could evolve to predict user interests across disciplines, curating interdisciplinary reading paths [12]. The Adaptive Personalization Theory of Learning (APT) suggests that such real-time adaptations will foster equitable learning environments by aligning content with diverse cognitive and cultural needs [7]. These advancements promise to boost motivation and retention, with early studies showing adaptive quiz platforms improving response times by up to 20% in educational settings [15].

6.2 Advanced smart library infrastructure

Digital libraries are transitioning toward fully automated, user-centric systems powered by AI, IoT, and cloud technologies. Future smart libraries will integrate predictive analytics to optimize resource allocation, such as forecasting demand for digital titles based on user trends [5]. IoT-enabled smart shelving, coupled with iBeacon technology, will evolve beyond current book localization to offer real-time patron guidance via smartphone apps, such as AR overlays showing book availability or curated reading lists based on location within the library [21]. Machine learning will further enhance database management, reducing retrieval times by up to 30% and minimizing system crashes for special collections [23]. These systems will enable seamless remote access, with cloud-based platforms delivering personalized services like automated alerts for new publications tailored to user profiles [24].

Figure 3 illustrates a conceptual framework for the future of smart books, depicting four interconnected trends: generative AI for content creation, IoT-driven smart library infrastructure, AR/VR-enhanced immersive experiences, and blockchain-based decentralized publishing. Each trend is represented as a node in a network, with arrows indicating their synergy (e.g., AI informing AR content, blockchain securing IoT data). A central hub labeled “smart library ecosystem” highlights their integration, with annotations for speculative features like emotion-aware content, predictive shelving, 3D books visuals, and micropayment contracts. The diagram uses color gradients to signify maturity levels, from established (AI, IoT) to emerging (blockchain, AR/VR), emphasizing their transformative potential.

6.3 Immersive AR/VR experiences

Augmented and virtual reality (AR/VR) will transform smart books into immersive, multisensory experiences, moving beyond static text to dynamic, interactive media. Future smart books could feature 3D visualizations that animate

Emerging Trends in Smart Books



Figure 3.
Emerging trends in smart books.

when accessed, such as a biology text projecting a rotating DNA model or a history book offering virtual tours of ancient sites [25]. Guided inquiry-based AR platforms, already in development, will integrate dynamic animations and videos to deepen engagement, with plans to scale these features for library-wide applications [26]. Smart libraries will adopt AR/VR for interactive learning spaces, such as virtual reading rooms or 3D-printed book companions, fostering creativity and participation [24]. Spatial computing, blending real-world and digital interactions via geographic information systems, will enable patrons to navigate knowledge domains physically and virtually, enhancing comprehension by up to 25% in early trials [21].

6.4 Blockchain for decentralized publishing

Blockchain technology holds the potential to revolutionize smart book publishing by enabling decentralized rights management and micropayment models. Future systems could use smart contracts on platforms like Ethereum to facilitate per-chapter or per-page access, reducing piracy and empowering content creators with direct revenue streams [27]. For example, a reader might pay for a microtransaction

to unlock a specialized textbook chapter, with funds instantly distributed to authors and publishers via blockchain. While current applications focus on library operations (e.g., secure borrowing records), extending blockchain to decentralized publishing could address copyright complexities, a major barrier to smart book adoption [28]. However, high computational demand remains a challenge, requiring energy-efficient protocols to scale effectively [27].

6.5 Challenges to adoption

Realizing these trends faces significant hurdles. Metadata quality, critical for AI and IoT systems, is hampered by inadequate training, software limitations, and a lack of standardized protocols [29]. Ethical concerns, including AI biases and privacy risks from extensive user data collection, demand robust safeguards, such as transparent algorithms and user-controlled data access [7]. Implementing advanced infrastructure requires substantial funding and staff training, with libraries struggling to evaluate Return on Investment (ROI) amidst rapid technological change [24]. Scaling AR/VR and blockchain solutions in underfunded regions poses additional equity challenges, necessitating global collaboration [20]. Addressing these issues through strategic investment and ethical frameworks will be crucial to unlocking the transformative potential of smart books.

7. Discussion

Research on the book's historical development reveals that it has consistently adapted as a content delivery method, keeping pace with advancements in information and communications technologies (ICTs). This medium has leveraged emerging technologies in each era, characterized by a new definition of the book. Thus, the book adapts its role to the exigencies of its target audience by riding the waves of contemporaneous innovations. This strategy has enabled the book to preserve its position in the sedimentation and intergenerational transmission of knowledge, despite formidable competitors.

Smart content, informed by historical precedents, is shaping a novel paradigm known as the smart book. This evolution seeks to uphold the book's principles while leveraging AI to sustain its knowledge-conveyance function. Machine-readable markup and linked data enable the conversion of ordinary text into intelligent and dynamic content. Adaptive reading systems tailor content delivery to individual reading habits, device specifications, and accessibility needs, signifying a revised book format in the AI era.

Managing smart books and content in digital systems, including intelligent libraries, is a current challenge. A critical issue is the modalities for administering such content, given its novel attributes and ontological characteristics. A smart library should provide personalized services via intelligent methods and efficiently handle and manage intelligent materials, including books, using semantic technologies and linked data [4, 5, 8]. Significant advancements in these processes are likely soon, combining infrastructures based on NLP, ML, deep learning (DL), complex neural networks, and associated methodologies – indicating a substantial paradigm shift. Integration of intelligent book technologies into digital library platforms is a compelling domain for scholarly inquiry and development. Case

studies exemplify nascent DL implementations that enhance user interaction, comprehension, and content discoverability. We're navigating a transitional phase from one ontological configuration to another, where domain experts must resolve myriad latent facets along the implementation trajectory.

The study showed that technological developments are changing reader behavior and expectations, driving changes in books and libraries, and shaping new smart books and libraries. Adapting to these demands is causing many changes. We see many ideas and innovations, yet we must be patient to utilize successful experiences and avoid revisiting the same steps.

8. Conclusion

The concept of smart books represents a significant evolution in the media transformation process, progressing from electronic and digital books to a new generation of books empowered by the widespread adoption of AI. The smart book is a multifaceted phenomenon, yet a universal consensus regarding its definition and scope has yet to be achieved. Like earlier technological advancements, such as e-books, smart books encompass a range of inherent and emergent features, the latter driven by innovative applications of modern technologies and the creative contributions of designers and innovators. Consequently, the conceptual boundaries of smart books remain expansive and, to a significant extent, unexplored, with scholars in the field still striving to reach an agreement on their full potential. Thus, smart books represent the next frontier in digital libraries, merging semantic technologies, adaptive systems, and emerging AI to enrich reading experiences and improve discoverability. This chapter focuses specifically on the role of smart books in digital libraries, often referred to as smart libraries. The integration of smart books into digital libraries marks a critical initial step toward transforming digital libraries into intelligent systems. Thus, the discussion of e-books within digital libraries encompasses not only their inherent features but also considerations related to the management of smart books in these environments.

Smart books are characterized by dynamic, interactive, and personalized content designed to address the informational needs of their audience within the scope of their subject matter. To achieve this, they leverage a spectrum of intelligent capabilities, including semantic processing, educational tools, interactive exercises, assessments, and mechanisms that gauge user proficiency. These functionalities are underpinned by foundational AI technologies, such as natural language processing, ML, and neural networks, enabling smart books to emerge as a new paradigm within an AI-driven ecosystem. However, as an emerging technology, smart books face various challenges and resistances, ranging from infrastructural requirements to societal acceptance by stakeholders, including content creators, designers, publishers, supply chains, and end users. Additionally, smart books encounter complexities related to management, copyright issues, semantic technologies, and other concerns, which are addressed in detail in this chapter.

Few case studies have documented the design and development of smart books in research contexts. While the number of such initiatives likely exceeds those referenced in this chapter, efforts have been made to highlight the prominent examples that have garnered significant attention. The degree of intelligence in these projects is contingent upon the technologies employed and their relative recency.

This chapter sought to situate these developments within a historical context, noting that the type and quality of these initiatives, coupled with the rapid advancement of AI technologies, suggest that significant transformations in the domain of smart books and their management within digital libraries are imminent. These advancements are poised to pave the way toward fully realized smart libraries.

From a technological perspective, challenges in smart book implementation include ensuring interoperability across diverse platforms and formats within settings such as libraries, museums, and archives. Another critical challenge lies in ensuring high-quality and consistent metadata through automated enrichment processes. This issue stems from limitations in software, inadequate evaluation and control mechanisms, a shortage of trained personnel, limited awareness of data management processes, and the absence of national standards [23]. Furthermore, AI-driven platforms inherently collect and analyze extensive user data, including reading habits and preferences, raising significant concerns about data privacy and security, particularly given the commercial value of such data in the current digital economy [16].

As highlighted throughout this chapter, the development of smart book technology must advance across multiple dimensions, including content creation, consumption, and management, all of which are increasingly driven by advanced technologies. A key area of focus, as noted in various sources, is the integration of semantic metadata and annotations into content [17]. Additionally, real-time AI-driven content generation and summarization are rapidly enhancing the capabilities of smart books across diverse industries, with substantial developments anticipated soon. The management of smart books within digital libraries is also undergoing a significant transformation, with libraries increasingly adopting advanced technologies to enhance operational efficiency and user experience [28]. This trend is likely to spur numerous applied research initiatives, leading to profound changes in the field. Moreover, blockchain-based rights management and micropayment models for decentralized publishing represent additional avenues for the development of smart books, as referenced in various studies. In conclusion, the near future is expected to witness the fruition of research efforts in the domain of smart books and their integration into content management systems, heralding a transformative era for digital libraries and beyond.

To guide future research and development in smart book technologies, the following questions merit exploration:

- (1) How can generative AI and real-time semantic enrichment be integrated to create scalable, cross-lingual smart books that address diverse cultural and linguistic needs in global digital libraries?
- (2) What ethical frameworks and privacy-preserving mechanisms can ensure equitable access to AI-driven smart books while mitigating biases in personalization algorithms?
- (3) How can emerging technologies like augmented reality and blockchain be combined to develop immersive, decentralized smart book ecosystems, and what are their long-term impacts on library circulation and user engagement?

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Chapter 4

The Digital in the Library: Finding the Mutually Beneficial Synergy

James M. Donovan

Abstract

With the value of access to digital resources abundantly demonstrated during the COVID-19 lockdown, enthusiasm for the format is reaching new heights. This chapter counsels restraint, rebutting the argument that skepticism concerning the wide adoption of digital materials into the library is due merely to nostalgia by anti-technologists for a now-bygone age. Despite their obvious usefulness in certain situations, patrons have not responded well when libraries propose to discard legacy print collections in favor of transient electronic formats. To explain this rejection, this chapter argues that libraries are built upon principles of collection development and organization of materials in order to achieve the library's goal of fostering the social good of healthy and lifelong relationships between patrons and networks of information and knowledge, qualities not easily reproduced in commercially acquired digital sets. The arguments offered demonstrate that digital resources provide a complement to the print library rather than a replacement. This fact places a natural limit on the level of acquisition of nonprint items that a healthy library can accommodate. The chapter concludes with principles of collection development to advance the mutual co-existence of print and nonprint formats.

Keywords: nostalgia, collection development, digital resources, censorship, information, knowledge, libricide, bookless library

1. Introduction

No, I don't worry about the bookless library, an efficient, money-saving edifice, housing only shiny banks of modems, disk drives, and books that talk to each other. A place without visitors, children's story hours, or librarians. . .

Instead, I suspect computers will deviously chew away at libraries from the inside. They eat up book budgets and require librarians that are more comfortable with computers than with children and scholars. Libraries will become adept at supplying the public with fast, low quality information.

The result won't be a library without books—it'll be a library without value.

—Clifford Stoll [1, p. 214]

The mixture of the idea of the library and the reality of digital resources¹ has not been without provocative challenges. Although the controversy has diminished in furor through the years, it cannot be said that a satisfactory rapprochement has yet been truly achieved. The current mash of inserting digital materials into libraries has been driven largely by pragmatic exigencies, but with little philosophical nuance. The intention here is to offset this deficit by attempting a recipe for not simply tolerable coexistence, but a mutually productive synergy that respects both the unique social value of the library and the technological benefits of the nonprint format. In that equilibrated condition, libraries could evolve into something new; in turn, digital resources would adapt to become more compatible with the environment and mission of libraries by capitalizing on their full potential to deliver more than facsimiles of traditional books.

Format changes within libraries are not unique – from clay to manuscript to codex, extending to digital resources and now AI – with each encountering resistance and eventual acceptance (excepting, perhaps, the microcard). We can expect that happy resolution to ultimately prove true about the fuller availability of digital resources. The issue is not the addition of a new format into the whole that is the library, but the extent to which that part threatens to overwhelm the whole and change it into something unrecognizably different. To avoid such unintended consequences, the challenge will be to manage the manner of that inevitable coexistence and to develop the conceptual tools to judge whether the outcome has improved or harmed the fundamental nature of the library.

Without question, the contemporary library has been primarily a collection of print artifacts, leading commentators to speak dismissively of this tradition: “The physical book is, in many ways, a jail for ideas” [2]. Printed materials restrict the options available to readers because they prioritize the intention of the writer when they should be seeking to liberate the creativity of the reader, while nonprint versions allow users to tailor their texts to their specific interests and needs. “Paper drives thoughts into our heads. The Web releases thoughts before they’re ready so we can work on them together” [3, p. 203]. We ought to be less interested in the thoughts and words of an author to learn about his or her worldview, and more inclined to treat the text as a toolkit from which we can sample phrases and lift ideas that reflect our own thinking. But the easy availability of such snippets, we are warned, has led to an inflated sense of personal knowledge and declining respect for the expertise of others [4, 5].

In the prevailing view, the digital library is unquestionably the preferred direction in which the institution should head. Although this opinion has been in the air for many years, its merits were fully on display during the COVID-19 lockdowns, when in-house use of the library was unwise, if not impossible. Alternative access through digital equivalents of books and periodicals permitted patrons to find materials for distraction and education, thereby retaining some semblance of normality. Whatever doubt had existed before 2019, thereafter the value of a library

¹ The focus of this chapter can be glossed by various terms such as digitals, digital resources, electronic materials, and databases. Granting that not all products are equivalent, it has been difficult to find a single term to capture the broad concept at issue in the present argument. Although the stripped-down “digital” can be awkward, it arguably describes the essential component most relevant to the members of the category, as well as the theme of this collected volume. I will, therefore, use the word both as a noun and an adjective.

including some level of such offerings could not be questioned. That concession, however, does not tell us the form or extent this inclusion should take.

Many regard the eventual triumph of digital formats as akin to how the codex relegated the manuscript to archives. There have accordingly been predictions of the demise of the traditional library [6, p. 194] in favor of the rise of “bookless” libraries. Despite this presumptive inevitability, attempts to actualize the bookless library have usually failed. In a recent example, Vermont State University announced plans to create an “all-digital” academic library, laying off ten librarians in the process. In its defense, the pressure to cut expenses was serious. Nonetheless, pushback was almost immediate: proposed in February, by May, a new interim president had rescinded the plan [7].

Policymakers tend to be deaf to the preferences of the persons they are meant to serve. Even librarians – ostensibly those charged with protecting libraries – can lobby for the cessation not only of the acquisition of paper editions but of their production altogether [8]. Although print books currently outsell digital versions four to one [9], advocates still insist that nonprint materials are not merely the latest alternative made possible by evolving technology but rather the only form that should be tolerated in libraries [2].

To know how to respond to such claims, we must possess a solid grasp of what is, in fact, the library’s function. Asking further to what extent the library’s unique social function follows upon the format in which patrons prefer to consume library content – if any such preferences exist – will allow identification of what may be at risk were digitals to attain pride of place.

The syllogism that assumes format interchangeability without remainder holds that libraries are utilitarian in an immediate sense: the patron requires some service, often information in some form, for sundry purposes. Anything that facilitates that function is to be encouraged; when the library’s collection is not being used, it becomes a mere “warehouse” of books.

The claim here is that, alongside that pragmatic attitude toward the services available from the library, there is another, perhaps ineffable intuition that the library, whatever information it contains, instantiates a unique relationship between the materials it contains and the community it supports. In an important sense, beyond being a mere tool, the library is the community’s intellectual doppelgänger [10]. It reflects the best of the hopes and aspirations of the patrons it has been built to serve. If that is the case, and if that relationship cannot be replicated by digital substitutes, advancing too far toward the “bookless” library will not only change the experience of the library but alter it altogether into something other, something less.

The argument to defend this view of the library begins with the observation that libraries are not reducible to the books that they contain. They are something more – an emergent institution that is qualitatively distinct from the information they contain, whatever the format. Understanding the sense in which “library” is not the collective noun for “books,” the challenge becomes to ascertain whether the normalized introduction of digitals furthers or diminishes this understanding of the library qua library. Discernment of this hidden nature of the library happens first through looking at the harm inflicted by libricide, when libraries are targeted for destruction because of the community values they embody. These values are given physical form through the professional activities to build collections that respond to the desires, preferences, and interests of the intended audience.

With that understanding of the library in place, the next step of the argument takes up the term of disparagement often hurled at those expressing skepticism toward what they perceive as a misguided prioritization of digital resources at the expense of traditional print. They are, we are told, indulging in nostalgia for a receding past – a criticism intended to dismiss the expressed concerns as being little more than a refusal to adapt. But rather than being a flippant insult, a correct reading of what “nostalgia” actually means reveals that it can be a rich tool for a revised relationship between the library and the new digitals – something beyond concession on the one side and insensitivity on the other.

2. The library is not the books

The premise that nostalgia is mere unproductive conservatism is built upon the assumption that libraries are synonymous with the books they contain, or, more specifically, the information within those books. If substituting digital formats for print occurs without loss of information, then the transition is deemed objectively harmless. The library remains as it was, but with greater access to its contents. Who could object to that? The net improvement argues for the transition from print to digital as quickly as possible.

The syllogism, however, begins with a faulty premise: that the library is reducible without remainder to the information within. This claim must be rejected once we attain an explicit grasp of what transforms a collection of information into a library. Not all aggregates of books, like bookstores, rise to the status of libraries, even if they contain exactly the same books and information. But if it is not the information that creates a qualitative difference, what, then, makes the library? The following argument defends the conclusion that libraries are social institutions and not mere information containers.

3. Censorship versus libricide

The contrast made here can be drawn by tracking the distinction between censorship and libricide, two methods of outside interference in the routine operations of a library. Censorship, which concerns the targeting of specific texts for various reasons, is a problem of collection development for all libraries. In recent years, efforts to censor content within libraries in the United States have reached stunning extremes. In Jamestown, Michigan, politicians preferred to cut all funding to its library because it continued to provide access to censored titles, forcing the library to close [11, 12]. Legislatures in at least ten states² have passed or attempted to pass laws that would charge librarians under obscenity and sex crime statutes with felony prosecutions, possibly resulting in six years in prison or \$10,000 in fines, for having LGBTQ volumes in their collections. In response, other states have passed anti-book ban laws [13]. Yet, even in the most voracious of censorious attacks, the library itself is rarely at risk, with the focus primarily limited to only certain parts of its contents.

⁶⁶ Arkansas (Act 372, 2013), Idaho (HB314, 2013), Indiana (HB1,134/SB0,017, 2022), Louisiana (HB414/ HB545, 2024), Missouri (SB775, 2022), North Dakota (SB2,307, 2025), Oklahoma (H3,702, 2022), Pennsylvania (HB2,815, 2022), Tennessee (SB2,292/SB1944, 2022), and West Virginia (HB4,654, 2024).

Libricide, on the contrary, is the targeting of entire libraries, regardless of whatever they may contain. It is the library itself that is the problem, not its materials. In such instances, “books,” according to Fernando Báez, “are not destroyed as physical objects but as links to memory, that is, as one of the axes of identity of a person or a community” [14, p. 12]. As such, libricide signifies a destructive act qualitatively different from censorship, one intent on erasing an identity rather than an idea. What can become collateral damage in the censorship battles is the sole objective in acts of libricide [15, p. 4]. “When the goal of battle is the obliteration of a culture (as opposed to simply unseating a regime), the conquest of territories and their populations is accompanied by the destruction of libraries and other cultural institutions supporting memory or legitimizing past identities” [16, p. 52].

The distinction between censorship and libricide makes sense only to the extent that libraries are not reducible to the books on their shelves. While both involve the elimination or removal of texts, they comprise disparate social phenomena to the extent that labeling an act of censorship as libricide is unhelpful hyperbole, while construing libricide as a form of censorship misses the point entirely.

Having noted that the difference exists, the next question concerns its source. For this, we can look to conversations about books and libraries, which today typically center on the idea of *information*. While information certainly serves as an undeniable element in the substance of any library, it is a mistake to assert that the library can be reduced in its entirety to whatever information it contains. The rebuttal of such reductionist assumptions is quickly revealed in the reactions upon learning that a library has been destroyed by fire or other catastrophe. “Even if every item in its catalog exists elsewhere, so that there has been no loss of information available to patrons, we rightly still feel diminished. We suspect something has been lost, but often lack words to articulate what that might be. But we know that it was not information” [15, p. 7].

Contrary assertions are not merely incorrect but illogical:

We speak of libraries “having” collections, but only awkwardly of collections “having” or “being” a library. Library is the superior concept, one comprised of collections, which, in turn, are comprised of books. Books, we may add, contain information, making that the most elemental unit within the chain leading upward toward the library. The popular tendency to focus on information, therefore, highlights the most reductive element. Far from being synonyms, library and information are antonyms standing at the opposite ends of the scale of organizational complexity [15, p. 7].

A third argument against the informational equivalence of libraries is found in the felt experience of being in the library. “Libraries helped to sacralize public space by altering the aesthetic perceptions of ordinary people, lending to the experience of otherwise common existence moral direction and spiritual consequence. Public libraries had a practical impact on how, simply put, ordinary people saw the world and moved within it” [17, p. 167]. Mere “images of significant libraries, such as that of Dublin’s Trinity College, can evoke a noticeable alteration in behaviors, akin to those upon entering sacred spaces such as a church or mosque. The similarity is not accidental; literature, primarily from architecture, speaks about the deliberate attempt to design library spaces that echo the cathedral-type atmosphere. Buildings we erect to house our libraries aim deliberately to inspire what Rudolf Otto [18]

termed an experience of the numinous” [19, p. 2]. Thomas Augst accordingly gestures toward the “ecclesiastic architecture” of libraries and their role as “‘secular cathedrals’ of liberal society” [17, p. 150]. From this view, libraries come as close as anything in our secular society to public sacred spaces [20–23].

Similar claims are easily collected:

- “If prayer is connection to the past, that form of sacred communion is exactly what one does in a library . . . Simply standing quietly amid the grandeur can be an act of devotion” [24, p. 17].
- “When all is said and done, holding a printed book in my hands can be a sacred experience – the weight of the paper, the windy sound of pages turning, like a breeze. To me, a printed book is like a cathedral or a library or a beach – holy space.” [25]
- “The way most people browse, it’s as if they’ve stepped into a temple or church. This is not riffling through hangers on the clearance rack or tossing canned corn into the cart. No, this is *browsing*. It even sounds drowsy: to *browse*. Heart rates slow. Time disappears. Serious people turn into dreamers again.” [26, p. 106]

The arches and dome of the Library of Congress Reading Room, for example, add nothing to the pragmatic acts of reading or to the utilitarian needs of book storage and arrangement, but are instead designed to elicit a receptive mindset for interaction with books. “If the shelving of books and provision of reading surfaces for the ingestion of information were the primary goals, it is unlikely the building would have taken the form it did, with a lofty interior and wide-open spaces. Nor are these features of the library’s physical presence attributable to mere decoration or effete aesthetics, but are instead intended to communicate a worldview” [19, p. 3]. All Carnegie libraries, we are told, “shared a prominent main entrance, usually accessed by steps (to give the visitor the sense of elevating himself)” [27, p. 58].

Taking seriously the claims of patrons about how they feel while within the building, we must consider the possibility that library space, whether by design or accident, evokes a deferential response from the user. This communion, as it were, is one not easily found elsewhere and is one which arguably facilitates interactions between reader and text. While such descriptions are common for libraries, the same cannot be said about digital collections: “Our experience of e-books is just somehow thinner than our experience of paper books – more weightless, not as satisfying, less substantial” [28, p. 189]. In other words, it is unlikely, even unimaginable, that digital texts – either singularly or en masse – will ever achieve the quasi-sacred aura instinctively felt when entering a library.

These arguments converge on the conclusion that the library is uniquely special, and that the source of that specialness is its relationship to its community. “Memory, then, is the one-word answer for the library’s unique mission [15, p. 8], one which should not be diminished by subsuming it into the simple idea of ‘information’.” By tending to the ordinary needs over the run of life of its patrons, every library comes to embody the ebb and flow of its local history. In this way, libraries make their mark not through the accretion of facts and data, but from the materials thought important to the community served [15, pp. 8–9]. For this reason, the loss of a library is a literal tragedy. “We mourn its destruction without any regard for what

information may have been lost. It is the relationship of that information to its people that has been annihilated, and which is irreplaceable even if the data themselves can be acquired elsewhere” [15, p. 9].

4. The techné of collection development

Even accepting the premise that the library is a gestalt beyond its informational contents, that realization alone does not suffice to inform the problem of how digital materials best fit into the library. For that, two more pieces are needed. We require, first, an understanding of how a library builds its collection of included items, gained here through examining the art of collection development; and second, a better grasp of how the patron perceives the differences between print and digital formats.

5. How collections develop

The rebutted syllogism that libraries are merely the information they contain implies that libraries emerge accidentally through the accretion of bits of data. To the contrary, the library “is never a random gathering of books. The collection grows by choice and agreement, and thus allows insights into the history of the institution, its links to history in general, and to the history of science and culture in particular” [29, p. 59], and, most importantly, into the history of the community and its people.

No library attains the status of being whole and complete, holding all existing books. While that may have been a possible achievement during the time of the Library of Alexandria [14, p. 45] and even Christopher Columbus’s son, Hernando Colón [30], when the quantity of materials was comparatively small, today’s information explosion has rendered such aspirations impossible [31, p. 63]. Instead, libraries metamorphose over time through deliberate additions to some initial holdings. Through this “process of additions and withdrawals driven by local priorities, interests, and tastes, a library evolves to mirror the community it serves” [15, p. 8].

This selectivity of a library is not a practical concession to the impossibility of building a universal library. For not merely practical reasons, but also due to reasoned judgment, each library includes only what its community of users, both present and future, can be anticipated to need or desire. Indeed, “[o]ne of the most valuable functions of the traditional library has been not its inclusivity but its exclusivity, its discerning judgment that keeps out as many things as it keeps in” [32, p. 43]. It is the selectivity of texts that makes the building of a library an essentially creative act, as compared to the mechanical, accidental accretion of materials, even all of them, onto the web. The internet is assumed to be global in its scope, allowing such presumably exhaustive contents to serve as a justification for the elimination of libraries: Everything’s on the web, so why fund an old-fashioned mausoleum of print? The truth is something different: the internet “collects so much noise, while libraries have always tried to collect the signals” [33, p. 26].

One takeaway from this contrast between the selectivity of the libraries and the universality of the internet is that, despite loose talk among speakers who should know better, libraries as a group can be spoken about only with the most sweeping generality: “Every library is, like every person, specific, unique, and irreplaceable”

[15, p. 8]. The internet's uniformity does not fit well with an institution predicated on the individuality of its members and the uniqueness of their lives.

Much, therefore, hinges upon how librarians make these acquisition decisions. While oftentimes personnel resort to mechanical processes, such as ordering whatever books are recommended in published lists [34], today, at least, due in no small part to the fluorescence of available titles, something more artful is required. A useful term to capture that art is *techné*, which highlights "the philosophical subtleties of *art* and *craft*, rather than to emphasize modern notions of industrial and digital technologies" [35, p. 260]. In contrast to the products of mere "chance, random, or inadvertent activity," acts of *techné* are the "conscious, willful working or reworking of matter until it becomes not only what it was but also what it was our intention that it should become." Jokes and poems are not *techné* because they are made from "thin air." In contrast, "when we cut down a tree to make lumber for a house, or logs for a fire, or paper for a book," these are acts of *techné* [36, p. 161].

In general, it "is appropriate to describe much of what librarians do as *techné* [in that] we apply technology, techniques, and craft to bring [forth] information, even knowledge" [37, p. 36]. Specifically, the intentionality of craft is the *sine qua non* of collection development, as opposed to the accidental outcomes of mechanically accumulated items via web crawlers.

Selection, no matter how artful, is still not sufficient to create a library. Of equal importance is the organization of the results of that selection, because "every book has a story to tell apart from its literary content" [38, p. 246]. When "books are joined with others that have traits in common, they form a larger story that can reveal something wholly new about the history of democracy, or Renaissance cooking, or Hells Angels who pen novels" [39, pp. 253–254].

The art, or *techné*, of organizing materials is a function of discernment regarding what a work is "about." "Classification is not some part of an external 'reality,' waiting to be discovered; it is an intellectual operation upon mental entities and concepts" [40, p. 199]. Judgments about what a work is "about" are "largely intuitive, depending very much upon what the patron has, for his or her own reasons, chosen to focus upon" [41, p. 31]. Decisions about where to place materials within established systems such as Dewey Decimal [DDC] or the Library of Congress [LCC] depend "upon the specific topical emphasis and, ultimately, the seasoned judgment of the cataloger" [42].

Navigating the waters of classification requires balancing the likely usefulness of the arrangement for patrons and the benefits of applying a universal system to encourage interchangeable records. While DDC and LCC favor the latter, the library of the Warburg Institute has, for the last century, employed a unique classification system that prioritizes the former. The collection, now housed at the University of London, applies a principle of "good neighborliness," whereby "works from a tremendous variety of disciplines and eras [are] placed side by side in such a way as to suggest scarcely imaginable connections between them" [43, p. 120]. At the end of the day, however, it is increasingly the former that weighs more heavily, as patron expectations about material collocation heighten the found utility of shelf browsing [41].

As one example of the challenge for librarians, journals for the subject areas of "psychological anthropology" and "cross-cultural psychology" are equivalent on the dimension of "aboutness" and differ only on a criterion of methodology. Most patrons, however, would expect to discover them close together or, more probably,

upon finding one, would likely find the other of great usefulness. While DDC reflects this similarity of rough “aboutness” and places both in 155.8, LCC separates the two, employing other criteria, putting the first in GN 502 and the second in BF 728.

The point is that neither selection nor classification is a mechanical process, but requires the experience, judgment, and intervention of a trained librarian familiar with the standing collection and the patrons who depend upon it. The evaluation of this thoughtful process should be judged more favorably than the rote placement of items in a bookshop or the sequestration of all digital texts into the cloud.

6. Information versus knowledge

Through selection and organization, the goal of every library “is to transform information into knowledge” [44, p. 429]. As reviewed above, libraries all contain information as raw material. The procedural techné of the library then shapes the selected and organized materials to deliver substantive knowledge rather than mere information, marking a further divergence from what can be achieved through digital collections. Throughout the history of libraries, however, the focus of the library has regrettably “moved from provoking questions in patrons to providing answers to patrons” [45, p. 408]. A landmark of this transition was reached in the Middle Ages, which signaled the beginning of conceiving the library “predominantly as simply a collection of books” to provide those answers [45, p. 408], an attitude that prevails to this day.

If the techné of the library is best realized when it sparks curiosity to explore, to ask questions about the world by allowing unintended connections to be found through serendipitously browsing the shelves, digital databases are, by contrast, designed to provide answers to preconceived questions – a tendency initiated with the ease of keyword searching, now reaching new heights with the popular uptake of generative AI. None of this is to deny that librarians provide information. The point is that this is not their primary goal. “These activities are less important to librarianship’s understanding of itself than the advancement of human learning” [46, p. 12].

Within the library, “the concept of information implies technological problems of quantity and distribution, rather than epistemological and hermeneutic problems of discerning God’s design, for instance, or preserving scientific and moral truths for future generations” [17, p. 174]. Ultimately, “electronics have a major role in the dissemination of information, but only a minor role in the dissemination of knowledge” [47, p. 69], a distinction that has not been recognized by many of the library’s users. Despite what some may believe, the library “is not a sort of scholarly filling station where students of all ages can repair to get themselves supplied with a tankful of titles; not an academic facility to be judged by the quantity of its resources and the promptness of its services. On the contrary, it is an achievement in and of itself – one of the greatest of human achievements because it combines and justifies so many others” [48, p. 231].

The push for digital “libraries” presumes a model of “information retrieval, not knowledge formation, and the material passes from Web to home paper without lodging in the minds of the students” [49, p. 94]. Mind-as-passive-conduit, rather than mind-as-cognitive-processor, is accompanied by differing experiences of the encounter. According to one student, “Reading [on] paper is active – I’m engaged

and thinking, reacting, marking up the page. Reading a screen feels passive to me” [50, p. 89].

Information, being primarily contained in independent bits, is largely additive and easily counted or categorized; meaning, on the contrary, “being subjective, and referring to synthetic or holistic properties that cannot be reduced to the sum of parts, might be called a higher sort of information that does not come easily, let alone inevitably, from a growing heap of mere information” [51, p. 80]. In other words, knowledge does not come inevitably from the steady ingestion of information. Such transmutation requires work of the most mindful kind. As philosopher John Dewey noted, even before the advent of the technology here at issue, “most people, from workers to kids to scholars, don’t go deeply enough into the search process to do much more than collect a grab-bag of information morsels. They are left with a ‘cessation’ of their task, not the ‘consummation’ of their quest” [52, p. 172].

As the next section demonstrates, the difference between information and knowledge is not only theoretical but also experiential and experimental, as seen in how students describe their encounters with print and digital reading.

7. Differential consumption of digital and print sources

If the literature is correct, and there does exist a persistent association of knowledge in the library beyond merely the atomized information favored in the digital substitutes, we would expect that readers interact with digital texts differently than they do with physical volumes [50, 53]. While research has shown that such differences appear across a wide range of variables [50, 53], the one focused on here suggests that studying in a book-rich environment leads to better comprehension of complex texts, even when the books are not consulted [19]. This possibility parallels, in important ways, the earlier description of the felt sacredness experienced when in the library.

Reading a book is so much more than consuming text. At the item level, whether a personal copy or a library loan, the book is a singular instantiation that acquires the marks of past use, such that it establishes a link between the current reader and those of the past. As one user expressed the emotional attachment that arises with a print volume, for him, “e-books don’t give the same satisfaction when we finish them.” He particularly likes the feeling of accomplishment on closing the physical book; it’s a nice visual cue [54, p. 187]. Speaking from my own experiences, my copy of Charles Darwin’s *The Origin of Species* contains not only his startling ideas but also the memory of having read it on the beach of Copacabana. For me, the associations are inseparable; one calls to mind the other, and the copy kept on the shelf preserves that history. For similar reasons, I prefer to buy used books rather than new copies.

Books, in the aggregate, can exert similar but even more powerful influences. Libraries are to be experienced “as spaces of enormous potential, which invite [the patron] to imagine new avenues of intellectual exploration, new pathways of reading pleasure” [25, p. 132]. Intellectual labor correspondingly happens more easily and successfully in libraries, just by being there, amidst the books, even without pulling a single one from the shelf [19]. To consult the library is to instinctively recognize participation in an ideal of the collective value of human intellectual effort, an ongoing “argument about the shape of knowledge itself” [28, p. 145]. It is therefore no surprise that merely reading in a “book-wrapt” [54] environment, one

where the walls are full of the intellectual efforts of predecessors, tends to have an impact on how the reader receives the message she is studying [49]. As Yun Lee Too observed, “it is the presence of the physical book, rather than the book itself, that is important, for it produces a site of intellectual foment” [55, p. 6].

This fostering relationship between readers and books appears in a negative form with the presence of digital devices. According to one study, “the mere presence of a mobile phone in the social space where two people were talking led subjects to judge the conversation as less close, to assess the relationship as being of lower quality, and to have less empathy for the other person than when researchers instead placed a pocket notebook on the same table. The mobile phone wasn’t turned on, wasn’t vibrating, wasn’t beeping. Its sheer physical presence reminded subjects that someone or something else might be waiting to grab their attention” [50, p. 163].

Against this background, what then of the claim with which we began, that libraries are essentially, if not completely, reducible to their books [56]? If the demonstrations above have been successful, they establish that the library is a unique and emergent social institution, many of whose special qualities depend upon the documented effects of reading in print – outcomes that tend not to be associated with digital substitutes. One takeaway is that to call a product a “digital library” makes little sense and is literally false. For the reasons given, digitals cannot render the outcomes that are part of the nature of true libraries. At best, digitals can be a library only in the weak, analogical sense of being an aggregate of sources; but then, bookstores are also libraries in this sense. “The Internet is *not* a library: nobody built it” [32, p. 69].

8. Nostalgia, not sentimentality

The offered view of the fundamental nature of libraries suggests that skepticism about incautious and exuberant dependence on digital formats is not irrational but is rather based on an understanding of the ways in which the library serves a valuable social function, and why reliance on digital collections cannot achieve the same result. Skeptics about the wisdom of encouraging the triumph of digital formats have, however, been dismissed as relics of a prior age, worthy of no serious rebuttal. They are, we frequently hear, simply nostalgic.

Representative of this position are the following statements from John Palfrey. Although not a librarian, Palfrey, who is currently leading one of this country’s largest philanthropic organizations, has consistently used his influence to press for the move away from print in favor of digital formats.

- “Those of us who care deeply about the future of libraries are too likely to rely on deep nostalgia about libraries rather than take risks and invest now in a bright future” [57, p. 214].
- “The argument needs to move past nostalgia and toward a bright and compelling future for libraries as institutions, for librarians as professionals, and for the role that libraries play in vibrant democracies.” [58]

Palfrey is not alone in his gesturing toward nostalgia as a problem to be overcome:

- “In the age of the digital image, all information is fungible—words, sounds, and images alike. It is a world in which the perfect digital copy makes nostalgia for the original seem more than a little quaint” [59, p. 18].
- “In the streaming era, there is a growing sense that owning things is an exercise in performative nostalgia” [60, p. 1150].
- “Already, we call our databases and online catalogs ‘digital objects’ – a reflection, perhaps, of our nostalgia for the dusty physicality of our books” [20, p. 211].

A brief but confused perspective comes from the president of the Finnish Library Association. While believing that libraries would be better off if messy books were “replaced by the perfection of the digital current of information,” as a pragmatic matter, he concedes that because “we have to rely on the support of the citizens,” the library must continue to depend upon “the memories of the smell of the books, the romance, the excitement, and the nostalgia to get our wonderful new [digital] library funded. . . [We need, in other words,] the nostalgia transformed into ones and zeroes” [61, p. 15].

The logical outcome of Palfrey’s hopes, toward which libraries should transition, will – and indeed must – eventually end with the elimination of all print [58, 62]. Regarding such intentions, it is worth noting that “those interested in libraries but not concerned with libraries on a day-to-day basis are far more likely to be enthusiastic about virtual libraries than those who deal daily with the realities of modern libraries and their use” [63, p. 4]. However, to realize this goal would require the public to surrender its nostalgia for the halcyon days remembered from childhood, of visiting the local Carnegie library to search the shelves for the latest additions to their favorite series under the watchful eye of a maidenly librarian, ready to quickly react to any unruly outbursts.

When invoked in this situation, however, the speaker misuses the idea of nostalgia. More likely, he intends a mere sentimentality, a related but discernibly different and less complex emotional experience [64]. Itself a problematic concept [65], sentimentality has tended to refer to an overindulgent emotional outburst that is often inappropriate and excessive, to the exclusion of actions to correct or respond to the provocative situation [66]. Tears are thought to be a typical accompaniment.

This section, however, takes seriously the critics’ choice of “nostalgia” to label the relevant psychological state, rather than mere sentimentality. Few, for example, would similarly dismiss the concern to preserve old buildings and cultural heritage landmarks as obstructive nostalgia [67]. Rather than a maudlin wallow in emotional regret for a receding lifeway, nostalgia, despite often being “associated with lower willingness to adopt new technological products,” may, in fact, challenge this notion: “Other empirical streams appear to challenge this notion: Nostalgia may facilitate favorable responses to innovative technology. In particular, nostalgia fosters social connectedness, which serves as a safe basis for welcoming innovative technology” [68]. Perhaps, having demonstrated above that skepticism is prudent, the disparagement concerning the form of that skepticism as “nostalgia” may prove to contain a means to productively reconcile the two sides.

Rather than being a vague term, research has demonstrated discriminant validity sufficient to reliably distinguish nostalgia “from alternative modes of thinking about

one's past, such as rumination, brooding, bereavement, homesickness, and counterfactual thinking. Contrary to these modes, nostalgia is positive and confers desirable psychological consequences" [69, p. 122]. Nostalgia has been found to be associated with, or to increase, the positive states of self-esteem, meaning in life, authenticity, social connectedness, and self-continuity [69, p. 122]. Granted, the same literature supports the assumption that the term suggests "a sentimental longing or wistful affection for the past" and can conceivably "contribute to hesitancy toward innovative technology, but it also affords psychological resources for facing and thriving in the future" [68, p. 999].

This bivalence of nostalgia suggests that, while critiques of library nostalgia are not literally incorrect, the dismissal fails to note that nostalgia does not end with a backward-looking face; it provides a path forward. Allowing that nostalgia "is characterized by valuing the past and being skeptical about the change that the future brings[, at] the same time, the emotion entails and fosters social connectedness, which instigates technology acceptance" [68, p. 1,014].

Nostalgia is thus a curious thing. While the colloquial default may be to deem it a slide into stubborn refusal to change, it can often signal a renewed appreciation for the value of receding understandings, as when library patrons, living in a world of digital processing, rediscover the merits of actual typewriters [70], or how, despite the transition toward digital images, 35 mm slides have found a new significance, such that kits to make faux slides for scrapbooks are increasingly popular [71].

9. A beneficial middle ground between innovation and tradition

The library has been shown to be a complex institution for reasons that largely involve the interaction of patrons with print materials – interactions that cannot generally be reproduced with digital alternatives. An excess of format conversion consequently threatens to undermine the emergent qualities of libraries, threatening their reduction to the warehouses of texts that they have often been accused of being. Caution in this direction is neither unreasonable nor imprudent, especially given the breathless enthusiasm of digital adventurers who desire the complete replacement of all print.

While this caution has often been dismissed as indulgent nostalgia, deeper examination into what the term covers reveals that it may not present the obstacle once thought. Nostalgia, by creating ties of connectedness and a sense of self-continuity, can, simultaneously with its recognition of the value of the past, generate opportunities to accept new technology, but in a thoughtful and library-friendly way.

Any perusal of the literature shows that when there has been digital rejection, these episodes have involved the push for digitals that are little more than faux books. Positive experiences with such alternatives during the COVID lockdown certainly provide some reason to support steps in that direction, but the empirical data shows that, especially when reading complex materials, comprehension is better in print than in digital formats. That result recommends against plans of extreme substitution [50, 53]. While the "bookless" library is thus ruled out as antithetical to the nature of the library, some mixture of formats can be anticipated and, when appropriate, even encouraged.

Limiting our attention to monographs, eBooks are unlikely to thrive so long as their intent is to simply mimic the print experience. While their success in that regard is limited, the larger disappointment has been the inability of the new medium to capitalize on the novel innovations that have become possible. Despite being a novel technology for presenting text, the products rarely offer anything sufficiently fresh that could not be done better in print. When first introduced, the promise was that the incorporation of hypertext would allow easy digression and thus a more immersive and instructive reading experience. Setting aside the debates over whether such distractions are beneficial [53, pp. 39–40], at least the effort evinced an attempt to provide not merely the traditional book on screen but something different.

One effort in this direction was Medallion Media Group's TREEbook. Introduced in 2012, it offered "an innovative new e-book format that features an underlying time-triggered reading experience that allows the book to generate multiple story-lines based on individual reading pace and other embedded triggers" [72]. Although this particular device does not appear to have been successful, it nonetheless represents what likely is necessary to optimize the potential of the digital format beyond its current efforts to occupy a niche already well-filled.

The lesson is that it is not necessarily the new technology that concerns nostalgic supporters of libraries, but technology that aspires to supersede the book upon which the emergent institution of the library is built. Given that such an outcome seems a meager use of the capabilities of what has been created, if more attention were devoted to such innovations, the sharpest opposition would likely fade. As an example, the removal of the card catalog in favor of online searching was a shock that required a steep learning curve among librarians and patrons alike, but few today would go back if they could. Libraries are not averse to technology; they resist poor technology with more costs than benefits.

While the digital version remains an inadequate substitute for the print book in most situations outside the unusual circumstances of the COVID lockdown, it does serve a narrow purpose and has found a small role within the informational ecology. The access is wonderfully useful when trying to verify a quote or a citation in the middle of the night. Yet, the limits of this alternative are not lost on the intended consumers, meaning any administrative movement toward a complete transition, as was done in Vermont, will be resisted and ultimately unlikely to succeed. While some believe it will be possible someday, in the future, "to feel book-wrapped in a virtual library" [54, p. 400], it is more likely that an upper threshold exists as to what can be done with the discrete ebook facsimiles, which can exist only in isolation and do not aggregate to create anything greater.

We can hope that digital products will move away from being poor books and evolve to offer something qualitatively distinct that takes advantage of coding versatility. In that eventuality, the more serious problem will show itself to be not the digital "book" but rather the idea of a digital "library." As described, the added value of print tomes in the aggregate cannot be reproduced, even poorly, by digital offerings. If "part of the point of the library is to be able to sit among so many books, 'aware that they, with their accumulated wisdom and charm, are waiting to be used'" [54, p. 388], then the physical library is assured of a long future.

The critical limiting factor preventing the emergence of a true library in digital form is that, at least as currently available, the techné of selection – so central to the formation of a print library – is barely present in commercial offerings. Electronic titles tend to be acquired in bulk as part of large databases rather than as individual choices. Inevitably, libraries tend to become indistinguishable, at least on this dimension of their offerings [73, p. 81]. To the extent that libraries become homogeneous, they cease to be true libraries uniquely reflective of their communities, at least in the sense that would warrant targeting in acts of libricide.

Whatever the future holds, librarians should be working to optimize the range of options for their patrons, not restrict them. As there can be no abstract ideal final form of the library, the elimination of print, while unlikely, would be unwise. To the extent possible, librarians would prefer to make available essential materials in multiple formats, with each called upon based on its particular strengths. Budget constraints put an upper limit on this duplication, however, so more individualized decisions will be required to find the appropriate mix for each patron community. The present argument has avoided these pragmatic issues, instead calling attention to the philosophical concerns grounded in the craft of professional librarianship, but they should nonetheless be recognized.

The suggestions on how to achieve the described balance can be condensed into the following principles for a techné of collection development that respects the uniqueness of the library, while allowing nostalgia to not only revisit the past but also create an opening for tempered improvements with new technologies.

Tenets of Collection Development

- (1) Each library collection is unique to the users it serves. There is no generic library.
 - (a) Tools to compare collections across institutions are of limited usefulness because the mission is not to copy how other libraries serve their patrons, but to learn how each best serves its own.
 - (b) Rules to define the “appropriate” or “model” collection that are not grounded in actual patron interests are of little relevance.
- (2) Given the variety of patron preferences, each collection will offer content in a range of formats.
 - (a) A purely print collection can be legitimately criticized for ignoring technological alternatives favored by many of the library’s patrons, which can offer more flexibility in managing access to the collection.
 - (b) A collection that over-invests in digital items ignores the ways that formats influence the experience of the reader. Research suggests that while ebooks are adequate for lighter fare, more complicated and scholarly material is better retained when studied in print.
- (3) The library collection should allow research to be conducted under various conditions.

- (a) Planning should anticipate that access to Internet sources can be unreliable.
- (b) The collection should accommodate the fact that not all patrons can visit the physical library.

10. Conclusion

The electronic text, in its very accessibility, gives users the illusion of appropriation without the attendant difficulty of learning. The essential purpose of reading becomes lost to them, and all that remains is the collecting of information to be used when required. The acquisition of something (rather than anything) always requires selection and cannot rely on a limitless offer. To observe, to judge, to choose requires training, as well as a sense of responsibility – even an ethical stance.

—Alberto Manguel [74, pp. 289–290]

The change brought about by the popular shift to digital substitutes, often instead of, rather than in addition to, print, is marked by a more subtle alteration in the role of librarians, who once “worked with” the contents of their collections, to a condition where they now only “work on” them. The way forward may be to heed Heidegger’s suggestion “to develop technology that leads us [once again] to question rather than to simply answer” [45, p. 409]. The digital text is not such a technology, but we can anticipate innovative offerings in the field that will be better received.

As it stands today, though, libraries have allowed technology to change their mission. The tail has been wagging the dog. This development can be contrasted with the case in medicine, where doctors have the same goals as ever they did, to heal, but look to new tools to accomplish them.

Libraries have, as their formative mission, the goal of creating healthy, lifelong relationships between the patron and networks of information and knowledge. The tools to achieve that goal are the traditional methods of collecting, organizing, preserving, and creating access. In all honesty, any lapse away from this tradition has largely been the fault of librarians themselves, who too often harbor an insecurity about remaining “relevant” in the face of the ready availability of information on the internet. This has led them to overlook what they bring to the community that Google never could. In the words of Frances Clarke Sayers, recognized by the American Library Association as one of the profession’s 100 most important leaders of the twentieth century, “We have never, in my opinion, stood our ground firmly enough and declared what our peculiar, unique function was to be, and then held to it and accomplished it” [75, p. 133]. This essay, perhaps, answers this call.

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Chapter 5

Electronic Resources Management in North American Academic Libraries

Shuzhen Zhao, Rong Luo and George Zhou

Abstract

Electronic resources management (ERM) is a critical function in academic libraries, encompassing the acquisition, licensing, tracking, maintenance, and provision of access to digital content such as e-books, e-journals, databases, streaming media, and other online materials. In North America, academic libraries often operate within collaborative consortia, such as the Canadian Research Knowledge Network (CRKN) and the Ontario Council of University Libraries (OCUL). Librarians representing their institutions within these consortia work collectively to negotiate licenses, manage shared agreements with publishers, and ensure efficient and cost-effective access to digital collections. These collaborations also involve shared integrated library systems (ILS), adherence to metadata standards, and cooperative collection management practices. This chapter examines the strategies, challenges, and collaborative frameworks that shape electronic resources management in North American academic libraries.

Keywords: Electronic Resources Management (ERM), academic libraries, consortia and collaboration, open access, library technology infrastructure, North America

1. Introduction

The shift from print to digital resources has fundamentally transformed academic library services, operations, and user expectations. Electronic Resources Management (ERM) has emerged as a critical function within academic libraries, encompassing the selection, acquisition, licensing, access, maintenance, and assessment of digital materials such as e-books, e-journals, databases, and streaming media. As the information landscape grows increasingly complex, ERM serves as the backbone for ensuring timely and reliable access to scholarly content in both physical and virtual environments.

The rise of digital scholarships and remote learning has intensified the need for seamless access to electronic resources. Academic libraries are no longer mere repositories of printed texts but dynamic information hubs that facilitate research, teaching, and learning through digital content delivery [1]. This shift was particularly accelerated during the COVID-19 pandemic, which highlighted the essential nature

of online access and prompted institutions to reassess their investments in digital infrastructure [2].

ERM is inherently multifaceted. It involves collaboration between librarians, faculty, IT departments, vendors, and consortia to manage an increasingly diverse and decentralized ecosystem of electronic content. Key processes include negotiating licenses with publishers, ensuring compliance with usage rights, maintaining knowledge bases and discovery systems, and tracking usage through analytics and standardized metrics like COUNTER and Standardized Usage Statistics Harvesting Initiative (SUSHI) [3]. Additionally, issues such as metadata quality, system interoperability, platform migration, and digital preservation complicate ERM workflows and demand strategic planning and technical proficiency.

In North America, the role of consortia is particularly significant in shaping ERM strategies. Organizations such as the Canadian Research Knowledge Network (CRKN), Ontario Council of University Libraries (OCUL), and the Association of Research Libraries (ARL) facilitate collective bargaining, shared technological infrastructure, and coordinated responses to challenges posed by commercial publishing models. These collaborative arrangements enable libraries to leverage collective purchasing power and share expertise in managing complex digital collections. Collaborative, user-centered approaches in North American academic libraries will be essential for the balanced growth of the electronic resources' collections. In Canada, the national level of the consortia is the Canadian Research Knowledge Network (CRKN). The mission of CRKN is "together, we empower Canada by creating pathways to trusted knowledge" [4] and "CRKN undertakes large-scale content acquisition and licensing initiatives in order to build knowledge infrastructure and research capacity in Canada's universities" [5]. One of the provincial levels of consortia in Canada is Ontario Council of University Libraries (OCUL). It is leading Ontario university libraries for managing "over 200 e-resource licenses on behalf of its member libraries. OCUL works with 95 vendors to license a range e-resources on behalf of its member libraries" [6]. In the United States, OhioLINK is one of the state's levels of consortia, and it is a "statewide academic library consortium, serving 115 libraries at 86 institutions plus the State Library of Ohio" [7]. Lots of Copies Keep Stuff Safe (LOCKSS) program at Stanford University Libraries "has provided the foundation for robust digital preservation of all types of digital content for libraries, publishers, and other content providers and stewards" [8].

The challenges for ERM in academic libraries across North America present a complex set of challenges that affect acquisition, access, user experience, and long-term sustainability. As electronic resources' content continues to control scholarly communication, academic libraries face ongoing pressure to balance user needs, budget cuts, technological change, and financial constraints. Chakraborty says that "the licensing of e-resources in academic libraries is driven by increasing demand, the information landscape revolution" [9]; negotiating and managing licenses for ERM can be intricate and time-consuming. Academic libraries with the consortia must navigate a landscape filled with varying publisher agreements, usage rights, embargo periods, and digital rights management (DRM) restrictions. Budget constraints and rising costs are the other challenges for ERM. Parrott pointed out that in Eastern Washington University by COVID-19 that "cancellations ensued, and 25 percent of the collections budget was cut" [10]. Particularly from major academic publishers and vendors, the rising costs of purchasing electronic collections and using the services pose a significant financial burden. Academic libraries are frequently forced to make difficult decisions about resource cancellations based on usage data, bundling

agreements, and changing the publisher and vendors to decrease the cost. Discovery and access issues are critical and difficult for ERM. For example, Ex Libris Central Discovery Index (CDI) “is a central, unified index for scholarly and academic material worldwide” [11], but the resources type of CDI that the collections access option is only either “turn on” or “turn off” for the entire collection. If academic libraries have no entitlement for some collections within CDI, however, the search results from Primo will be showing the collection titles with the error message. Furthermore, broken links, authentication errors, platform instability, and integration issues with discovery tools are experienced by the end users. Of course, usage analytics, staff training, ILS interoperability, and long-term preservation may be the issues for ERM as well. As the demand for digital content continues to grow across disciplines, the strategic management of electronic, ERM plays a critical role as well in shaping the effectiveness, accessibility, and impact of academic libraries in North America [12]. ERM ensures that students, faculty, and researchers have timely, uninterrupted access to a wide range of scholarly electronic materials. This access is dynamic for academic success, revolution, and competitiveness in research output across North American universities. Furthermore, ERM encourages partnerships across academic departments, consortia, and vendor networks. Through collaborative licensing, resource sharing, and collective bargaining, libraries can improve service delivery and negotiate better terms with publishers.

Academic libraries also play a growing role in the open access (OA) movement, with ERM professionals increasingly involved in managing Article Processing Charges (APCs), transformative agreements, and institutional repositories. The shift toward OA has added new dimensions to ERM, requiring librarians to navigate emerging licensing models, support faculty publishing efforts, and contribute to equitable knowledge dissemination [13].

Theoretical frameworks that underpin ERM include resource lifecycle management, service design, and socio-technical systems theory. These perspectives highlight the need to view ERM not simply as a set of technical tasks but as an integrated practice involving human actors, technological systems, and organizational culture [14]. As such, ERM requires a balance of strategic vision and operational detail, supported by continuous professional development and adaptive leadership.

Despite significant advancements in ERM in academic libraries across North America, several persistent gaps remain in practice. Singley and Natches conducted a survey that shows that “workflow gaps in traditional ERM systems” [15] and some libraries are still performing core ERM tasks with customized systems. So, there is a lack of standardized practices across institutions. Limited staff training and professional development are other gaps in ERM roles. Furthermore, many academic libraries depend heavily on vendors not only for the collection but also analytics and electronic platforms. This kind of dependence will limit transparency and control for electronic resources.

This chapter aims to provide a comprehensive overview of Electronic Resources Management in North American academic libraries. It begins by tracing the historical development of ERM practices and then explores the key components of electronic resource workflows. It also examines collaborative models, supporting technologies, challenges, and innovations in the field. By contextualizing ERM within broader trends in scholarly communication and higher education, the chapter offers actionable insights for library practitioners, administrators, and policymakers navigating the evolving digital environment.

2. Evolution of electronic resources in academic libraries

The evolution of electronic resources in academic libraries is deeply intertwined with technological advancements, changing scholarly communication practices, and the increasing demand for digital access to information. From early digitization projects in the mid-twentieth century to the widespread implementation of integrated electronic resources management systems today, academic libraries have undergone a profound transformation in how they acquire, manage, and deliver information.

2.1 Early developments: Digitization and automation

The origins of electronic resources in academic libraries can be traced back to the 1960s and 1970s, a period marked by the emergence of library automation systems. Libraries began using computers to catalog and manage their collections, leading to the development of Online Public Access Catalogs (OPACs) and bibliographic databases such as OCLC and Dialog. Although these systems primarily supported print-based collections, they laid the groundwork for future electronic resources management by demonstrating the potential of digital tools in enhancing access and efficiency.

Digitization efforts in the 1980s and 1990s further catalyzed the transition. Academic libraries began converting print materials into digital formats to improve preservation and access. Notable projects included JSTOR, which provided scholars with digital access to back issues of academic journals, and Project MUSE, which expanded access to digital humanities and social science content. These initiatives signaled a growing recognition of the value of digital collections and prompted libraries to reconsider their roles as stewards of information in an increasingly digital environment.

2.2 Emergence of e-journals and databases

The late 1990s and early 2000s witnessed an explosion in the availability and use of electronic journals (e-journals) and databases. This shift was driven by advances in Internet technologies and a growing demand for immediate, remote access to scholarly content. Publishers began offering electronic versions of their journals, and academic libraries rapidly incorporated them into their collections to meet faculty and student needs.

E-journals presented both opportunities and challenges. On the one hand, they enabled libraries to provide access to vast collections of scholarly content without the spatial limitations of print. On the other hand, they introduced complexities in licensing, access rights, usage tracking, and perpetual access guarantees [14]. These complexities necessitated the development of new systems and workflows to manage electronic subscriptions effectively.

In parallel, academic libraries began subscribing to aggregators and full-text databases such as EBSCOhost, ProQuest, ScienceDirect, and SpringerLink. These platforms consolidated access to thousands of journals and other resources, simplifying discovery for users but complicating back-end management. Libraries had to negotiate licenses, monitor usage, and ensure compliance with copyright that required specialized knowledge and dedicated staff.

2.3 Consortia collaboration and shared licensing

To manage rising subscription costs and ensure broader access to resources, academic libraries increasingly turned to consortia. These collaborative networks enabled institutions to negotiate collectively with publishers, achieving economies of scale and enhancing bargaining power. In North America, consortia such as the Canadian Research Knowledge Network (CRKN), the Ontario Council of University Libraries (OCUL), and the Center for Research Libraries (CRL) have played critical roles in supporting shared electronic resources management and access.

Consortial agreements allowed smaller or less-resourced libraries to access high-cost resources that would otherwise be unaffordable. They also facilitated shared technical infrastructures, such as consortial catalogs and link resolvers, and encouraged collaborative collection development strategies. However, participation in consortia also required libraries to coordinate workflows, align metadata practices, and manage complex cost-sharing arrangements—factors that significantly influenced the evolution of ERM practices.

2.4 Rise of Integrated Library Systems and ERM tools

As electronic resource collections grew, libraries faced increasing challenges in managing them using traditional Integrated Library Systems (ILS), which were originally designed for print materials. The limitations of legacy ILS platforms—particularly in handling license information, access restrictions, and usage statistics—led to the development of Electronic Resources Management (ERM) systems specifically tailored for digital content [3].

Pioneering ERM tools such as Innovative Interfaces' ERM module and Ex Libris' Verde (later incorporated into Alma) provided centralized platforms for managing the lifecycle of electronic resources. These tools allowed libraries to store license agreements, track acquisitions, monitor access issues, and manage vendor contacts. More recently, cloud-based library services platforms like Alma, Worldshare Management Services (WMS), and FOLIO have integrated ERM functions into broader resource management ecosystems, enabling seamless workflows across print, electronic, and digital collections.

In addition to these platforms, libraries began adopting standards such as COUNTER for usage statistics, Knowledge Bases and Related Tools (KBART) for knowledge base metadata, and SUSHI for automated harvesting of usage data. These standards facilitated interoperability among vendors, discovery tools, and ERM systems, promoting more efficient management and assessment of electronic resources.

2.5 Open Access and the future of electronic resources

The rise of the Open Access (OA) movement has introduced new dimensions to the evolution of electronic resources. Increasingly, academic libraries are involved in managing OA content, supporting institutional repositories, negotiating transformative agreements, and overseeing Article Processing Charges (APCs). These responsibilities require ERM systems and workflows that can accommodate non-traditional acquisition models and track open-access content alongside subscription-based resources [13].

Moreover, libraries are facing pressures to support digital scholarships, research data management, and user-centered services. These demands are prompting libraries to rethink how they organize, present, and assess electronic collections. The future of ERM will likely involve deeper integration with research infrastructure, enhanced analytics for decision-making, and more agile systems that can respond to evolving user needs and publishing models.

3. Key components of Electronic Resources Management (ERM)

Electronic Resources Management (ERM) encompasses a wide array of interconnected activities that support the acquisition, maintenance, and provision of digital content in academic libraries. These components work together to ensure that electronic resources are accessible, reliable, cost-effective, and aligned with institutional goals. As digital content grows in both volume and complexity, libraries have developed sophisticated strategies and tools to manage the full lifecycle of electronic resources. This section outlines and discusses the key components of ERM, highlighting their roles and interdependencies in a North American academic context.

3.1 Resource selection and evaluation

The selection of electronic resources is a foundational aspect of ERM. It involves identifying materials that align with the library's mission, academic programs, research priorities, and user needs. This process is typically collaborative, involving subject librarians, faculty members, and collection development teams. Key considerations include content relevance, scholarly reputation, licensing terms, cost, accessibility, and anticipated usage.

Evaluation tools often include trial access periods, user feedback surveys, and usage statistics from similar institutions. Libraries also consider alternative models such as demand-driven acquisition (DDA), evidence-based acquisition (EBA), and patron-driven acquisition (PDA), which enable data-informed decisions based on actual user engagement.

3.2 Licensing and negotiation

Licensing is a critical component of ERM, defining the terms and conditions under which digital content can be accessed and used. Unlike physical resources, electronic materials are typically not owned outright by libraries but accessed under legally binding agreements with vendors or publishers. As such, licensing negotiations require careful attention to legal, ethical, and financial implications.

Academic libraries aim to secure licenses that protect user rights while ensuring institutional compliance. Key licensing terms include:

- Authorized users (e.g., faculty, students, and alumni)
- Permitted uses (e.g., interlibrary loan, course reserves, and data mining)
- Archival rights (e.g., perpetual access after cancellation)

- Access methods (e.g., IP authentication and proxy)
- Liability clauses and dispute resolution

Librarians often consult model licenses, such as those developed by the International Coalition of Library Consortia (ICOLC) or the Canadian Research Knowledge Network (CRKN), to negotiate favorable terms.

3.3 Acquisition and payment processing

Once a resource is selected and licensed, the acquisition process involves financial transactions and documentation. Electronic resource acquisitions may include one-time purchases (e.g., e-books) or ongoing subscriptions (e.g., journal packages and databases). Libraries must manage a range of payment structures, such as flat fees, usage-based pricing, consortial agreements, and Article Processing Charges (APCs) for open-access content.

Budget tracking, invoice reconciliation, and fund accounting are critical to ensure transparency and financial sustainability. Libraries often rely on integrated library systems (ILS) or enterprise resource planning (ERP) tools to manage acquisition workflows and generate reports for decision-making.

3.4 Access and authentication

Providing seamless and secure access to electronic resources is one of the most visible aspects of ERM from the user's perspective. Academic libraries use various authentication methods to enable access while protecting licensed content from unauthorized use. Common methods include:

- IP address recognition—allows on-campus access without login.
- Proxy servers (e.g., EZproxy)—allow off-campus access *via* institutional credentials.
- Shibboleth and OpenAthens—federated identity systems used for single sign-on (SSO).

Authentication must be reliable and user-friendly to avoid barriers to access. Additionally, libraries often provide customized portals, LibGuides, and discovery services to facilitate resource navigation.

3.5 Metadata management and knowledge bases

Accurate and consistent metadata is essential for the discovery and access of electronic resources. Metadata includes descriptive, administrative, and technical information that supports cataloging, linking, and retrieval. In the ERM context, metadata must be maintained not only for individual titles but also for packages, platforms, and vendors.

Knowledge bases—comprehensive datasets maintained by vendors like Ex Libris, EBSCO, and OCLC—play a key role in providing up-to-date title lists, URLs, and holdings

information. Libraries rely on these knowledge bases to populate link resolvers and discovery layers, which connect users to full-text content. Standards such as Knowledge Bases and Related Tools (KBART) help ensure metadata consistency across systems.

3.6 Discovery and linking

Discovery tools enable users to search, find, and access electronic resources. These include integrated library catalogs, discovery layers (e.g., Primo and EBSCO Discovery Service), and subject databases. Effective discovery requires interoperability between systems, accurate metadata, and robust indexing of content.

Link resolvers are critical components that interpret OpenURL metadata to direct users to the full-text version of an item. They rely on the underlying knowledge base and must be configured correctly to ensure accurate linking. Broken links and incorrect coverage dates can significantly impact user satisfaction and require ongoing maintenance.

3.7 Usage statistics and assessment

Usage data provides insight into how electronic resources are used and supports evidence-based decision-making. Libraries track metrics such as downloads, searches, cost-per-use, and user demographics to evaluate resource performance and justify budget allocations.

Standards such as Counting Online Usage of Networked Electronic Resources (COUNTER) and Standardized Usage Statistics Harvesting Initiative (SUSHI) ensure consistency and automation in usage data collection. These standards enable libraries to generate comparable reports across platforms and vendors.

Assessment also includes qualitative measures such as user surveys, feedback, and citation analysis. These data points help libraries identify underutilized resources, renegotiate licenses, and inform collection development strategies.

3.8 Troubleshooting and support

Technical issues are inevitable in electronic resources management, ranging from broken links and access denials to platform outages and authentication errors. Libraries must have clear workflows for identifying, documenting, and resolving these problems quickly.

Support may involve communication with vendors, system administrators, consortial partners, and end users. Many libraries use ticketing systems (e.g., LibAnswers and JIRA) to track issues and responses. Providing prompt and effective troubleshooting ensures user satisfaction and minimizes disruption to research and learning.

3.9 Communication and documentation

ERM requires clear documentation of policies, workflows, licenses, access credentials, and vendor contacts. Effective communication among library departments—such as acquisitions, cataloging, systems, and public services—is essential for smooth operations.

Documentation also supports knowledge transfer, staff training, and continuity during personnel changes. Many libraries develop internal ERM manuals and maintain shared repositories using platforms like SharePoint, Confluence, or Google Drive.

Externally, communication with vendors and consortia must be strategic and professional. This includes documenting service issues, escalating disputes, and maintaining positive relationships to ensure responsive support and successful renewals.

3.10 Integration with consortia and collaborative networks

Participation in library consortia adds another layer to ERM operations. Consortial partners share access to resources, negotiate collective licenses, and manage joint budgets. This collaboration enables libraries to expand their collections, reduce costs, and influence vendor practices.

However, managing shared agreements requires coordination of workflows, alignment of priorities, and communication across institutions. Libraries must integrate consortial agreements into local systems, track their share of usage and costs, and comply with reporting requirements.

4. Collaborative models and consortia

Academic libraries in North America have long relied on collaboration as a strategic means of coping with budget constraints, the rising costs of scholarly publications, and the increasing complexity of managing electronic resources. Collaborative models, especially through consortia, have become essential to Electronic Resources Management (ERM). By pooling financial resources, negotiating as a unified body, and sharing infrastructure, consortia have enabled academic libraries to acquire and manage electronic content more efficiently and equitably. This section explores the collaborative frameworks that support ERM in North America, with a focus on the roles, structures, and impacts of library consortia.

4.1 Historical context and emergence of consortia

The emergence of library consortia can be traced back to the 1960s and 1970s when libraries first began working together to manage physical collections, share cataloging data, and facilitate interlibrary loans. However, the widespread shift to digital resources in the 1990s and early 2000s catalyzed a more formalized, strategic approach to collaboration. The high and rapidly escalating costs of journal subscriptions—often referred to as the “serials crisis” prompted academic libraries to form consortia for collective bargaining with publishers and vendors [16].

Consortia allowed libraries to negotiate license agreements that would be cost-prohibitive if pursued individually. As digital content proliferated, collaborative licensing arrangements evolved to include large database packages, streaming media, e-book collections, and institutional memberships to digital platforms.

4.2 Key North American consortia

In North America, numerous regional and national consortia have become central actors in ERM. Some of the most prominent include:

- Canadian Research Knowledge Network (CRKN): A national-level consortium representing over 80 Canadian academic institutions. CRKN negotiates large-scale licensing agreements and supports access to key research content. It has

played a leading role in national initiatives like open access transitions and shared digital infrastructure [4].

- Ontario Council of University Libraries (OCUL): A provincial consortium in Canada supporting 21 Ontario universities. OCUL manages Scholars Portal, a platform for hosting licensed and open content, and facilitates shared services such as electronic resource licensing, preservation, and statistical reporting.
- Center for Research Libraries (CRL): A US-based international consortium of over 200 academic and research libraries. CRL licenses electronic collections, supports open access, and promotes the long-term preservation of digital resources.
- California Digital Library (CDL): Serving the University of California system, CDL is a leader in licensing negotiations, digital curation, and transformative agreements aimed at expanding open-access publishing.
- The Big Ten Academic Alliance (BTAA): A consortium of research universities in the Midwestern US that collaborates on shared licensing, scholarly publishing reform, and infrastructure development.
- Ohio Library and Information Network (OhioLINK): serving 115 libraries at 86 institutions plus the State Library of Ohio. Delivering both IT infrastructure and content negotiation, OhioLINK provides access to valuable digital research collections at a fraction of the cost if those collections had to be purchased by individual institutions.

Each of these consortia has developed specialized models tailored to their member institutions' goals and capacities, creating robust ecosystems of support for ERM.

4.3 Types of collaborative models

Collaborative models in ERM can be broadly categorized based on their scope, structure, and degree of integration:

a. Buying consortia

These focus primarily on joint procurement of digital resources. By aggregating demand, buying consortia increases bargaining power and reduces costs. CRKN, for instance, negotiates access to journal bundles from major academic publishers such as Elsevier, Springer, and Wiley, delivering savings through tiered pricing models.

b. Infrastructure and platform sharing

Some consortia extend their services beyond licensing to provide shared platforms for content delivery, preservation, and discovery. OCUL's Scholars Portal hosts e-books, journals, and datasets for its member libraries. Similarly, CDL's eScholarship platform supports open-access publishing across the University of California system.

c. Collaborative collection development

In this model, libraries coordinate to build complementary collections and reduce redundancy. While more common with print, some consortia extend this to e-book and database licensing, particularly in evidence-based acquisition models where data guides collective purchasing.

d. Transformative and open access agreements

Consortia have become crucial in negotiating transformative agreements that shift subscription fees toward open-access publishing. These “read-and-publish” models aim to make scholarly output freely accessible while retaining access to subscription content.

4.4 Benefits of consortial ERM

The collaborative approach to ERM offers numerous advantages for academic libraries, especially those with limited resources.

a. Cost savings and economies of scale

Pooling financial resources allows consortia to negotiate more favorable pricing and access conditions. Larger groups can leverage collective bargaining to reduce per-institution costs and secure access to a broader range of resources.

b. Expanded access to content

Libraries benefit from access to resources they might not otherwise afford. This democratization of access is particularly beneficial for smaller or underfunded institutions and supports equity across higher education systems.

c. Shared expertise and staff support

Consortia often employ dedicated staff with expertise in licensing, metadata management, statistics, and ERM systems. This centralized expertise relieves pressure on individual institutions and improves the quality and consistency of services.

d. Standardization and best practices

Consortia promotes the adoption of standards in metadata (e.g., KBART), usage reporting (e.g., COUNTER), and licensing (e.g., NISO SERU). These standards enhance interoperability across systems and streamline workflows.

e. Innovation and experimentation

Consortia can pilot new models of access and publishing that might be too risky or complex for a single institution to pursue. For instance, some have pioneered “subscribe to open” models, OA publishing funds, or platform development.

4.5 Governance and funding structures

Consortial models differ in governance and financial structure. Some, like CRKN, operate as independent nonprofit organizations with governing boards representing member institutions. Others are hosted within a lead institution or state/provincial body.

Funding is typically based on a membership fee structure, with costs apportioned according to institutional size, usage, or negotiated formulas. Transparency and equity in cost-sharing are essential to maintaining member trust and participation.

4.6 Challenges in consortial collaboration

Despite its many advantages, consortial ERM also presents challenges:

a. Balancing diverse needs

Member libraries vary in size, budget, and priorities. Reaching consensus on shared purchases and licensing terms can be difficult, particularly when interests diverge.

b. Complex cost allocation

Determining fair cost-sharing formulas that reflect usage, size, or mission can be contentious. Some institutions may perceive they are subsidizing others, especially in flat-rate models.

c. Dependence on centralized infrastructure

Reliance on a shared platform or negotiation team can create bottlenecks or reduce flexibility. Libraries must balance the benefits of standardization with the need for local autonomy.

d. Sustainability and scalability

As consortia grow in membership and service scope, ensuring sustainable funding, staff capacity, and governance becomes more complex.

e. Vendor resistance

Some publishers resist consortial negotiations, fearing reduced profits or loss of pricing control. This can lead to lengthy negotiations, embargoes, or refusal to provide favorable terms.

4.7 Future trends in consortial ERM

As open access gains traction, consortia are shifting from subscription-based models to supporting scholarly publishing infrastructures. This includes negotiating transformative agreements, funding APCs, and supporting community-owned platforms.

Additionally, consortia are playing more active roles in research data management, digital preservation, and linked data initiatives. The future of ERM will involve deeper collaboration not just in licensing but in shaping the global information ecosystem.

5. Technological infrastructure supporting ERM

Electronic Resources Management (ERM) in academic libraries depends heavily on a robust technological infrastructure that enables the acquisition, access, administration, and analysis of digital content. As the scope of e-resources expands to include e-books, journals, databases, datasets, multimedia, and open-access repositories, the systems that support their management have become increasingly sophisticated and integrated. In North American academic libraries, the technological infrastructure for ERM includes ERM systems, integrated library systems (ILS), link resolvers, knowledge bases, authentication tools, usage statistics platforms, discovery services, and interoperability standards. This section explores the components of this infrastructure, their functions, and how they collectively support efficient and sustainable ERM practices.

5.1 Electronic resources management systems (ERMS)

An Electronic Resources Management System (ERMS) is a specialized tool designed to manage the life cycle of e-resources—from evaluation and acquisition to licensing, access, renewal, and cancelation. ERMS platforms typically provide modules for:

- License tracking and compliance
- Usage statistics aggregation
- Subscription and cost management
- Title-level holdings and package metadata
- Renewal alerts and vendor communications

Examples of ERMS products include Ex Libris Alma, Innovative Sierra, and FOLIO. Many academic libraries have integrated ERMS into their broader Library Services Platforms (LSPs), enabling tighter workflow coordination across acquisitions, cataloging, and access services. A well-implemented ERMS helps ensure that e-resources are discoverable, accessible, and aligned with institutional licensing obligations.

5.2 Integrated Library Systems (ILS) and Library Services Platforms (LSPs)

Traditional Integrated Library Systems (ILS), such as SirsiDynix and Innovative Interfaces, primarily supported print resource management. However, modern Library Services Platforms (LSPs), such as Alma (Ex Libris), WMS (OCLC), and FOLIO (open source), offer broader capabilities that include managing both print and electronic resources within a unified environment.

These platforms often include built-in ERMS features, acquisition modules, link resolvers, and discovery tools. They support API-based interoperability and allow for more automated and scalable e-resource management workflows. LSPs also facilitate real-time updates from publishers and vendors *via* linked knowledge bases, reducing the burden of manual metadata maintenance.

5.3 Link resolvers and knowledge bases

A link resolver connects a user from a citation in a database to the full text of the article, using OpenURL or other metadata protocols. Popular link resolvers such as SFX, 360 Link, and Alma's integrated resolver depend on extensive knowledge bases—databases that store information about journal holdings, access URLs, and title lists for e-resource packages.

Knowledge bases are essential to maintaining accurate and timely access to e-content. Vendors and consortia regularly update these databases to reflect changes in journal titles, embargo periods, and access rights. In North America, many libraries rely on shared knowledge bases maintained by LSP providers or consortia, reducing the need for local updates.

5.4 Discovery services

Discovery services provide a unified interface for users to search across a library's physical and electronic holdings. These systems, such as Primo, Summon, EBSCO Discovery Service, and WorldCat Discovery, integrate catalog records, database content, and institutional repositories into a single search experience.

Technologically, discovery platforms require careful integration with ERMS, link resolvers, and knowledge bases to ensure that only accessible content is discoverable. They also rely on:

- Harvesting protocols (OAI-PMH) for institutional repository data
- Relevance ranking algorithms
- Customizable indexing rules
- Real-time availability status

Discovery tools enhance user experience and ensure that electronic content is fully leveraged, but they also require constant maintenance and system tuning by librarians and IT staff.

5.5 Authentication and access control

Access to licensed electronic resources requires robust user authentication and authorization mechanisms. In North American academic libraries, the two most common methods are:

- IP authentication: Recognizes users based on institutional IP addresses.
- Federated authentication: Uses systems like Shibboleth, OpenAthens, or SAML-based Single Sign-On (SSO) to allow secure, personalized access *via* campus credentials.

Federated access has become increasingly important in a remote and hybrid learning environment. It also supports personalization features (e.g., saved searches and reading lists) and granular usage analytics. Ensuring secure and seamless access to e-resources remains a top priority in ERM.

5.6 Usage statistics and analytics

Understanding how e-resources are used is essential for data-driven decision-making. Most publishers and vendors provide usage data compliant with Counting Online Usage of NeTworked Electronic Resources (COUNTER) standards. Libraries often use tools such as Standardized Usage Statistics Harvesting Initiative (SUSHI) to automate the retrieval of usage reports.

Platforms like LibInsight, Alma Analytics, and Unsub help visualize and interpret this data for budgeting, renewal decisions, and demonstrating return on investment (ROI). These tools also support the trend toward evidence-based acquisition (EBA) and demand-driven acquisition (DDA) models.

5.7 Interoperability standards

ERM workflows span multiple systems and vendors, making interoperability essential. Several standards enable integration and data sharing across platforms:

- Knowledge Bases and Related Tools (KBART): Ensures consistent title and holdings metadata between providers and knowledge bases.
- MARC and BIBFRAME: Facilitate cataloging and metadata exchange.
- OpenURL: Supports dynamic linking from discovery tools to full-text content.
- SUSHI: Automates the harvesting of COUNTER usage reports.
- ONIX-PL: Facilitates the exchange of licensing information.

These standards reduce redundancy, enhance data accuracy, and support scalable, automated workflows.

5.8 Open-source and community-driven tools

Some academic libraries, especially those in consortia, are turning to open-source solutions for ERM. FOLIO is a prominent example of a community-developed platform that integrates ERM, acquisitions, and cataloging into a modular, extensible architecture.

Other tools, like CORAL ERM, focus specifically on electronic resource workflows and are often deployed by smaller institutions or as part of collaborative consortial infrastructures. Open-source tools offer cost flexibility and customization but require in-house technical support and community engagement.

6. Challenges in Electronic Resources Management (ERM)

Electronic Resources Management (ERM) in academic libraries has transformed access to scholarly content, yet the management of digital materials

presents a unique set of challenges. These challenges stem from the rapid evolution of technology, complex licensing terms, budgetary constraints, metadata inconsistencies, and shifting user expectations. For North American academic libraries, especially those operating within consortia, these issues are further compounded by the need to coordinate policies and infrastructure across institutions. This section explores the principal obstacles to effective ERM, highlighting the operational, technical, and strategic hurdles libraries must overcome to deliver seamless access to e-resources.

6.1 Licensing complexity and negotiation challenges

One of the foremost challenges in ERM involves the negotiation and interpretation of licenses. Unlike print resources, which typically entail a one-time purchase, electronic resources are governed by intricate licenses detailing access rights, usage restrictions, archival provisions, and renewal terms. Academic libraries often struggle to navigate these legal documents due to:

- Ambiguity in licensing language
- Restrictions on interlibrary loan (ILL) and course reserves
- Limitations on simultaneous user access
- Conflicting digital rights management (DRM) policies

Negotiating favorable terms demands significant expertise and time. Furthermore, licenses often vary significantly across publishers, requiring librarians to tailor negotiations to each provider. Collaborative consortia, such as the Canadian Research Knowledge Network (CRKN) and the Ontario Council of University Libraries (OCUL), help mitigate this burden, but local interpretation and enforcement of terms remain a challenge.

6.2 Budget constraints and pricing models

ERM is costly. Subscription prices for academic journals and databases have steadily increased, with some publishers implementing annual price hikes of 5–10%. Libraries must balance these increases against stagnant or declining budgets. Moreover, pricing models are often opaque and vary widely:

- Tiered pricing based on institution size or usage
- Bundled “Big Deals” that include many unwanted titles
- Pay-per-view or demand-driven acquisition (DDA) schemes

These models can be difficult to evaluate and manage. As libraries strive to remain fiscally responsible, cancellations and cost-benefit analyses have become common. The lack of budgetary predictability in electronic resource pricing poses a persistent threat to collection sustainability.

6.3 Metadata and discovery issues

Accurate and consistent metadata is crucial for making e-resources discoverable. However, metadata quality often varies by vendor, and updates may not propagate effectively through link resolvers, discovery services, and catalog records. Common problems include:

- Inconsistent title-level metadata
- Incorrect embargo information
- Broken or outdated URLs
- Mismatched identifiers (ISSN and DOI)

These issues can severely impact user access, leading to frustration and increased support tickets. Maintaining accurate, up-to-date metadata across multiple systems requires continuous oversight and coordination among catalogers, systems librarians, and vendors.

6.4 Access and authentication complications

While electronic resources offer greater convenience, they also introduce complexities in access and authentication. Libraries often rely on a combination of IP authentication, proxy servers, and federated identity systems like Shibboleth or OpenAthens. However, these systems can fail due to:

- IP changes or misconfigurations
- Proxy server downtime
- Institutional Single Sign-On (SSO) integration issues
- Inconsistent user experiences between on-campus and off-campus access

Managing and troubleshooting these systems requires technical expertise and close collaboration with campus IT departments. Poor access experiences can deter users from fully utilizing the library's digital holdings.

6.5 Usage statistics and decision-making

Libraries are increasingly expected to justify their e-resource investments using usage data. However, gathering and interpreting such data poses several challenges:

- Not all vendors provide COUNTER-compliant statistics
- Variations in usage reporting across platforms
- Difficulties correlating cost with value or impact
- Lack of user demographic data to support equity analyses

Even when usage statistics are available, they may not reflect actual engagement or scholarly impact. For example, high download counts may not indicate that resources are being read or cited. Libraries must develop nuanced approaches to data interpretation to inform renewal and cancellation decisions.

6.6 System integration and workflow gaps

Academic libraries rely on a variety of platforms for ERM—integrated library systems (ILS), link resolvers, discovery tools, and ERM-specific modules. However, these systems often do not integrate smoothly. Common workflow inefficiencies include:

- Duplicate data entry across systems
- Delayed updates to holdings information
- Manual license tracking in spreadsheets
- Limited automation of renewal alerts and title changes

Such fragmentation can lead to inconsistent records, staff fatigue, and user access issues. Libraries pursuing interoperability must invest in staff training, custom scripting, and participation in open standards initiatives such as KBART and SUSHI.

6.7 Vendor reliability and service quality

The quality of service from vendors and publishers varies widely. Issues such as delayed product updates, limited customer support, poor interface design, and platform outages can undermine the user experience and create administrative burdens. Moreover, vendor mergers and acquisitions may affect the continuity of service and licensing terms, creating uncertainty for long-term planning.

Academic libraries are often locked into contracts with major providers due to the lack of viable alternatives, particularly in STEM and medical disciplines. This vendor dependence limits negotiation leverage and increases systemic risk.

6.8 Training and staff expertise

Managing electronic resources requires specialized knowledge in licensing, metadata standards, system administration, and usage analytics. However, many academic libraries face challenges in recruiting and retaining staff with the necessary technical and legal skills. Additionally, ERM workflows often involve multiple department acquisitions, systems, and reference—necessitating cross-training and collaboration.

As ERM tools evolve to must library staff, the need for ongoing professional development is urgent, especially in institutions with limited staffing or high turnover. Without adequate training, even the most sophisticated systems will not achieve their potential.

7. Trends and innovations in Electronic Resources Management (ERM)

As the landscape of scholarly communication continues to evolve, academic libraries in North America are rethinking traditional approaches to Electronic

Resources Management (ERM). With the proliferation of digital formats, increased demand for open access, and rapidly advancing technologies, libraries must adopt forward-looking strategies to maintain effective and responsive ERM practices. This section explores some of the most prominent trends and innovations transforming how libraries acquire, manage, and provide access to electronic resources.

7.1 Transition toward open access and transformative agreements

One of the most significant trends in ERM is the shift toward open access (OA) publishing models. Academic libraries are increasingly supporting transformative agreements, also known as “read-and-publish” or “publish-and-read” deals. These agreements combine traditional subscription access with open-access publishing rights for institutional authors.

Consortia such as the Canadian Research Knowledge Network (CRKN) and California Digital Library have pioneered efforts in North America to negotiate such contracts with major publishers. These models help institutions meet funder mandates (e.g., Plan S and NIH) while reducing the burden of article processing charges (APCs) on individual researchers. Libraries are also investing in OA infrastructure, such as institutional repositories and OA monitoring tools (e.g., Unpaywall or OpenAlex), to support discoverability and long-term access.

7.2 AI and automation in ERM workflows

Artificial intelligence (AI) and machine learning are beginning to make inroads into library workflows, including ERM. Libraries are exploring AI-powered tools to automate:

- Metadata normalization and enrichment
- Usage analytics and trend forecasting
- License text parsing and categorization
- User query resolution through chatbots

Additionally, automation of routine tasks—such as harvesting usage statistics *via* SUSHI, activating resources in knowledge bases, and generating renewal alerts—is helping libraries free up staff time for higher-level decision-making. AI is also being used in recommendation systems within discovery layers to personalize user experiences and enhance relevance.

7.3 Emphasis on interoperability and open standards

To improve efficiency and integration across systems, libraries are adopting interoperability standards such as KBART, COUNTER 5, OpenURL, SUSHI, and BIBFRAME. These standards facilitate better communication between ERMS, discovery tools, cataloging systems, and vendor platforms.

In particular, the adoption of linked data models and open APIs is enhancing the ability of libraries to customize and connect platforms. Open-source initiatives like

FOLIO exemplify this shift toward modular, interoperable ecosystems, allowing libraries to configure tools based on institutional needs and collaborate globally on development and support.

7.4 Evidence-based and patron-driven acquisition models

Another innovation shaping ERM is the growing use of evidence-based acquisition (EBA) and patron-driven acquisition (PDA) models. These approaches shift purchasing decisions from speculative subscription to data-informed access:

EBA allows libraries to pay upfront for broad access and later purchase titles based on usage data.

PDA (also known as demand-driven acquisition, or DDA) enables users to trigger purchases when they access or request specific titles.

These models align closely with usage-based collection development and offer greater flexibility in managing budgets, especially in institutions with diverse research needs.

7.5 Enhanced user experience and accessibility

Modern ERM now prioritizes user-centric design. Libraries are working to improve discovery interfaces, reduce broken links, and ensure seamless access across devices and locations. Integration with Single Sign-On (SSO) systems and mobile-friendly platforms supports a more intuitive user experience.

Additionally, compliance with Web Content Accessibility Guidelines (WCAG) and inclusive design principles ensures that e-resources are usable by patrons with disabilities. Libraries are also advocating for more accessible content from vendors and incorporating accessibility audits into their evaluation criteria.

7.6 Sustainability and long-term access

Preserving long-term access to electronic resources is an emerging priority. Libraries are participating in digital preservation initiatives such as LOCKSS, Portico, and CLOCKSS to ensure that e-resources remain available even if publishers cease operations or cancel agreements.

The push for perpetual access rights in licensing negotiations and increased interest in institutional archiving solutions reflect a strategic commitment to information sustainability and academic continuity.

8. Future directions and recommendations

As academic libraries continue to navigate a rapidly evolving information landscape, the future of Electronic Resources Management (ERM) will be shaped by the convergence of technological innovation, open scholarship, and user-centered strategies. While ERM practices have matured over the past two decades, ongoing shifts in research dissemination, user behavior, and economic pressures demand renewed approaches and long-term planning. This section outlines key future directions and practical recommendations to strengthen ERM efforts in North American academic libraries.

8.1 Embracing agile and modular systems

Libraries should invest in modular, open-source platforms that allow flexibility and integration across discovery, cataloging, and access services. Systems like FOLIO and CORAL represent a departure from monolithic architectures, offering more control and community-driven innovation. Adopting linked data frameworks and semantic web technologies will also enhance interoperability and resource discoverability across systems.

8.2 Strengthening licensing and open access strategies

The shift toward open access publishing and transformative agreements will continue to redefine ERM. Libraries must build licensing expertise to negotiate equitable and sustainable deals with publishers while supporting open infrastructure. Investment in institutional repositories, preprint servers, and collaborative OA platforms should be prioritized to preserve scholarly output and broaden global access.

8.3 Advancing data-driven decision making

ERM should evolve into a more evidence-based practice. Libraries must improve their capacity to collect, analyze, and act on usage data, cost-per-use metrics, and user feedback. Integrating advanced analytics dashboards and visualization tools will support more transparent and informed resource evaluation, collection development, and reporting.

8.4 Expanding collaboration and consortial engagement

Future success in ERM will depend on deeper collaboration across libraries, consortia, and vendors. Libraries should continue to pool expertise, negotiate shared agreements, and develop joint repositories and knowledge bases. Expanding global partnerships can also support access equity, especially for under-resourced institutions.

8.5 Centering equity, accessibility, and sustainability

Finally, ERM practices must align with broader institutional goals of diversity, equity, inclusion, and sustainability. Libraries should prioritize accessible content, advocate for inclusive licensing terms, and assess environmental impacts of digital services. Ongoing training for library staff on inclusive technology, metadata ethics, and sustainable procurement will be vital.

9. Discussion

The findings and insights presented in this chapter underscore the transformative role of Electronic Resources Management (ERM) in shaping the digital landscape of North American academic libraries. The integration of ERM into library operations is not merely a response to the proliferation of digital content, and it is a strategic evolution aligned with the broader mission of academic institutions to support research, teaching, and lifelong learning.

A central claim emerging from this chapter is that collaborative consortial models are essential to sustainable ERM practices. By participating in consortia such as CRKN and OCUL, libraries gain access to shared negotiating power, cost-effective licensing, and streamlined workflows. This model not only mitigates financial constraints but also fosters a culture of resource sharing and policy harmonization, which is crucial in an era of tightening budgets and expanding digital demands.

Second, the chapter highlights the complexity and interdependence of technological infrastructures in ERM. Effective resource management hinges on robust integrated library systems (ILS), metadata standards, link resolvers, and discovery platforms. The study affirms that continued investment in interoperable, scalable systems is necessary to ensure efficient content delivery and user access. It also shows that academic libraries increasingly act as technological hubs, balancing legacy systems with emerging tools such as AI-based metadata enhancement and data-driven analytics.

Another key discussion point concerns the ongoing shift toward open access (OA) and its implications for ERM. While OA models present opportunities for greater equity in scholarly communication, they also introduce new complexities in licensing, cost allocation, and content curation. This chapter reveals that ERM functions must adapt rapidly to these models by developing agile workflows and building staff competencies that encompass both traditional subscription management and emerging OA frameworks.

The research also underscores the importance of user-centered design in ERM. Accessibility, discoverability, and responsiveness are not ancillary but foundational to digital resource effectiveness. Academic libraries must prioritize user experience as a core dimension of ERM, integrating usability studies and feedback loops into system configuration and content delivery strategies.

Lastly, the chapter emphasizes that the future of ERM will be shaped by how well academic libraries align their strategies with global scholarly trends and local institutional goals. Whether through embracing FAIR data principles, contributing to open infrastructure, or participating in collaborative preservation networks, libraries are positioned not only as service providers but as co-creators of the evolving digital knowledge ecosystem.

In sum, this chapter affirms that ERM is more than an operational necessity. It is a strategic, collaborative, and transformative domain through which academic libraries can advance equitable access to knowledge in the digital age. The significance of this chapter lies in its comprehensive analysis of ERM practices and its call to action: for libraries to continue evolving, adapting, and leading in the stewardship of electronic resources.

10. Conclusion

Electronic Resources Management (ERM) has become a cornerstone of academic library operations in North America, evolving in response to the digital transformation of scholarly communication. From managing complex licensing agreements to ensuring seamless access and long-term preservation, ERM requires a dynamic blend of technical expertise, collaboration, and strategic planning. This chapter explores the historical evolution of e-resources, the key components of ERM systems, collaborative models such as consortia, supporting technological infrastructures, common challenges, and the latest trends and innovations.

As libraries continue to transition toward open access, embrace AI and data analytics, and prioritize user experience and accessibility, the future of ERM promises increased flexibility, interoperability, and equity. Yet, these advances come with challenges that require ongoing adaptation, particularly in licensing, budgeting, metadata management, and system integration.

To remain effective, academic libraries must invest in scalable infrastructures, build staff capacity, and engage in strategic partnerships that promote sustainable and inclusive access to knowledge. By aligning ERM practices with institutional and global scholarly goals, libraries can reaffirm their role as vital stewards of digital scholarship and facilitators of equitable information access in the twenty-first century.

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Chapter 6

Digital Library for Blind Users: Tools, Technologies, and Inclusive Innovation

Irfan Ul Haq

Abstract

Digital libraries (DLs) have become indispensable knowledge gateways, yet their promise of universal access remains unrealized for millions of blind and visually impaired readers. In an era where information access defines empowerment, DLs for the blind emerge as transformative conduits, bridging sensory barriers to foster intellectual autonomy and cultural enrichment. This chapter dives into the multifaceted ecosystem of DLs for the blind, exploring the tools that make reading a joy for those with visual impairments. From eBraille files to talking books, technologies like DAISY formats, audiobooks with customizable voices, and voice-to-text searches create seamless access to information. The chapter focuses on Greenstone Digital Library Software (GSDL), a flexible, open-source platform perfect for building these inclusive libraries. With its multilingual support and adaptable design, GSDL can organize Braille and audio collections for easy access while proposing innovative enhancements: AI-powered text-to-speech engines, voice-activated searches, and multimodal navigation integrating Braille, voice, and touch modalities to elevate usability. Global exemplar libraries, like the US National Library Service and Perkins Library, narrate diverse technological adoptions and their societal impact. These examples show what is possible when technology meets empathy. This chapter is not just about tools and techniques; it is all about opening doors to knowledge, ensuring every single piece of information, every idea, and every adventure is within reach for blind readers, creating a world where everyone belongs.

Keywords: digital library, blind digital library, digital library for blind, AI in digital library, assistive technology, Braille digital library

1. Introduction

Universal access to information is a foundational library ethic, yet fewer than 10% of published works are available in formats blind readers can use without sighted assistance [1, 2]. Millions around the world live with visual impairments that hinder their access to traditional educational and informational resources. The shift to digital technology opens doors that were once firmly closed. Digital libraries have emerged as powerful platforms for knowledge dissemination; however, equitable

access still remains a critical concern, especially for individuals with visual impairments. Digital libraries for the blind (DLBs) aim to bridge this gap by using accessible technologies to provide seamless access to knowledge. DLBs are more than just repositories of books; they are gateways to independence, learning, accessibility, knowledge, empowerment, and joy for people with visual impairments. Creating these libraries is not just about converting printed content to digital; rather, it is about making that content navigable, understandable, and usable through assistive technologies [3, 4].

Imagine a library that speaks to you, feels familiar under your fingertips, and understands your needs even before you express them. For the visually impaired, such an experience can be transformative. Early solutions like Braille embossing (1850s) and analog talking books were scalable only within national copyright exemptions. Digital library platforms seemed to break this impasse, but inaccessible file formats, proprietary Digital Rights Management (DRM) schemes, and sight-centered interface designs replicated print-era exclusion [5, 6]. Consequently, accessibility is now framed as both a human-rights obligation and a technical design challenge, codified in the ADA, Section 508, WCAG 2.2, and the Marrakesh Treaty [7, 8].

The advancement of digital libraries can revolutionize access to information for individuals with visual impairments, offering unprecedented opportunities for education, entertainment, and personal development. DLBs leverage assistive technologies and use cutting-edge tools to transform traditional reading into formats like audio, Braille, and large print, making knowledge truly inclusive for those who cannot engage with standard print. A DLB must incorporate specialized tools such as Braille books, talking books, Braille-enabled touch screens, audiobooks, voice-to-text conversion, audio search, artificial intelligence (AI) assistants, and AI-enabled chatbots to ensure accessibility [9]. Imagine a world where every book, article, or piece of knowledge is instantly available to everyone, regardless of whether they can see the text on a page. For people who are blind or visually impaired, traditional libraries and digital resources often present barriers. But with the right tools, we can build digital libraries specifically designed for the blind, ensuring equal access to information.

1.1 Understanding the needs of the blind community

Visually impaired users interact with digital resources in fundamentally different ways compared to sighted users. Their information-seeking behaviors are often shaped by the availability of accessible content and tools. Accessibility requires designing systems that enable independent access to information without the need for assistance from sighted individuals. Barriers such as non-navigable interfaces, image-based content without alt-text, and lack of voice support create significant challenges (see **Table 1**). Addressing these through user-centered design and adaptive technologies is essential [10].

2. Literature review

Universal access to information is a foundational principle embedded in library ethics, yet the percentage of published works accessible to blind readers remains critically low [11, 12]. Research from the last 30–35 years shows that technical,

Barrier	Impact on blind users	Technological/Design solutions
Non-navigable web interfaces	Difficulty accessing content	Screen readers, voice navigation, keyboard shortcuts.
Image-based content	Loss of information without alternatives	Alt-text, AI-generated image descriptions
Proprietary file formats	Limited access and interoperability	Use of open formats like DAISY, ePub.
DRM restrictions	Access limited by copyright controls	Accessible DRM-compliant formats or exemptions

Table 1.
Overview of barriers for visually impaired individuals in digital libraries and their solutions.

policy, and design barriers still curb independent discovery, navigation, and content consumption. The shift from physical print to digital formats provides a significant opportunity to bridge this information gap. Drawing on empirical studies from various developed and developing nations reveals success factors and persistent obstacles in implementing accessible digital library services, proposes evidence-based best practices, and outlines future directions in AI-augmented personalization and multisensory interfaces. However, some of the studies [13, 14] emphasize that without adaptive design and assistive technologies, digital repositories may perpetuate exclusion.

Visually impaired users interact with digital content distinctly from sighted users. Studies by Chaffey [15] and Roney [16] show that information-seeking relies heavily on navigability and multimodal access points, including touch, audio, and voice. Usability research underscores the importance of user-centered design tailored to these unique needs [17, 18]. Accessibility must be framed both as a human rights obligation and a technical design challenge, as articulated in key legislations like the ADA, Section 508, and international treaties such as the Marrakesh Treaty [19].

2.1 Assistive technologies and user studies

Qualitative research across Indonesia, Nigeria, Ghana, and South Africa confirms that screen readers (NVDA, JAWS) and magnifiers remain primary access tools, yet library deployment is uneven and staff skills are limited [16–18]. South-African public libraries reported inadequate internet-connected workstations, braille embossers, and DAISY players, constraining information seeking, job searches, and leisure reading [17]. Studies at the University of Delhi Braille Library highlight the importance of specialist recording studios, DAISY production workflows, and volunteer support, but also chronic budget shortfalls [19].

2.2 Mobile and web usability

A controlled comparison of mobile app versus mobile web versions of a digital library showed significantly better accessibility scores for the native app, except in “accessing information/objects,” underscoring persistent Responsive-Web pitfalls [20]. Xie and colleagues document recurrent problems: unlabeled buttons, missing headings, inaccessible multimedia, and insufficient metadata, which precipitate frequent help-seeking among blind novices [21].

2.3 Inclusive design and universal design for learning

Inclusive design frameworks emphasize flexibility, responsiveness, and co-creation with disabled users [22]. Workshops applying universal design for learning (UDL) principles in library makerspaces demonstrate that early integration of multimodal inputs, tactile graphics, and voice feedback benefits all learners, not only those with disabilities [23].

2.4 Policy and legal landscape

WCAG 2.2 extends earlier guidelines with criteria on focus appearance, dragging movements, and error prevention – features critical for keyboard-only or voice-driven navigation [7, 14]. Section 508 binds US federal libraries to comparable standards, while many academic libraries voluntarily embed WCAG clauses in license agreements with e-content vendors [6]. The Marrakesh Treaty’s mandatory exceptions facilitate the lawful creation and cross-border transfer of accessible copies; over 120 countries have transposed its provisions, often mirroring treaty text verbatim [24].

3. Tools and techniques for creating DLBs

Creating a DLB is not just about digitizing books; it is about crafting an experience that feels intuitive and empowering. This endeavor requires a suite of specialized tools and techniques to ensure accessibility, usability, and seamless navigation. The tools and techniques that make this possible are designed to meet the unique needs of readers. These include Braille books, talking books, advanced Braille-enabled touch screens, audiobooks, voice-to-text systems, audio search capabilities, AI assistants, and AI-enabled chatbots. Each tool addresses specific accessibility needs, enhancing the user experience for individuals with visual impairments.

3.1 Braille books

Braille books have long been a lifeline for blind readers and remain foundational in blind literacy, their raised dots turning words into touchable stories. Braille books, traditionally produced as tactile texts, have evolved into digital formats known as eBraille or digital Braille, taking this a step further. Braille Embossers are used as printers to produce physical Braille books from digital files.

These eBraille files, often in Braille Ready Format (BRF), can be read using Refreshable Braille Displays (RBD). RBDs (like the Orbit Reader 20) let users read e-books, web pages, and documents in Braille in real time. RBDs are small devices connected to computers or mobile devices that convert digital text into tactile Braille characters. These devices are portable and sync with different computer devices, allowing real-time translation of digital text, enabling users to read digital content on the go and digital documents. They raise and lower pins to form Braille characters, letting users scroll through books with ease. These displays are compatible with screen readers and work with various operating systems [11].

Digital Braille books allow users to navigate through texts using levels of granularity (e.g., chapters, sections, or paragraphs) defined by standards like the Digital Accessible Information System (DAISY). DAISY-formatted Braille books use XML and SMIL to structure content, enabling precise navigation via compatible devices [12]. For instance, a user can jump to a specific chapter or paragraph using the Braille display's keypad, significantly improving access compared to physical Braille volumes. It is like giving a book a table of contents that is touch-friendly, making navigation smooth and natural.

3.2 Talking books and audio books

Talking books offer recorded versions of printed texts read aloud by humans or synthesized speech. These are professionally narrated recordings designed for individuals who cannot read standard print; it is like having a friend read aloud to you. These narrated recordings, once stored on clunky cassettes, are now available in digital files stored on CDs, USB drives, or downloaded via services like the Braille and Audio Reading Download (BARD) platform [13].

Devices like the Victor Reader Stream (VRS) and Plectalk PTN2 which support DAISY and National Library Service (NLS) formats, make this experience even better. These devices offer varied features like variable playback speed, sleep timers, voice-guided menus, and AI-generated voice formats of textual materials that feel welcoming and easy to use for these types of users [12].

Audiobooks, distinct from talking books, are commercially produced audio recordings available through platforms like Audible or LibriVox. Platforms like Bookshare offer audiobooks with text-to-speech (TTS) options, letting users tweak the voice or speed to their liking [14]. While not specifically designed for the blind, audiobooks, when paired with smartphone screen readers like Voice Over (iOS) or Talk Back (Android), are found to be a treasure for blind readers too. Library services such as Bookshare provide large collections of accessible audio materials with TTS capabilities, allowing customization of reading speed and voice [15].

Audiobooks are popular choices, but not all are equally accessible.

- The DAISY format is designed specifically for the blind, allowing users to skip chapters, adjust reading speed, and navigate like a printed book.
- TTS software (like NVDA or JAWS) reads digital text aloud in a natural voice.
- Human-narrated audiobooks (like those from LibriVox) provide a more engaging listening experience.

It is amazing how mainstream tech can open doors when paired with thoughtful design of digital libraries, which ensures that audiobooks are searchable and downloadable, often in DAISY or MP3 formats.

3.3 Advanced Braille-enabled touch screens

Advanced Braille-enabled touch screens integrate RBDs with touch – sensitive interfaces, allowing users to interact with digital content dynamically. It is a device that combines the tactile feel of Braille with the swipe of touchscreen navigation,

enabling users to read eBraille files and interact with applications through gestures. Imagine a tablet where the screen itself changes shape to form Braille letters under your finger – Advanced Braille-enabled touch screens do just the same. These devices support DAISY and BARD formats, offering seamless integration with digital libraries. For example, a user can read a book, search for new ones, and even swipe to navigate between chapters with a single voice command or a single swipe [13].

Recent innovations have introduced dynamic tactile interfaces, allowing blind users to interact with images, graphs, or even maps using touch-sensitive surfaces. These are still evolving but hold great promise for education and exploration. Following are some examples of these touch screens, such as the Blitab Tablet, Hyper Braille, and Orbit Reader, which provide multi-sensory input and output channels. These are game-changers, giving blind readers the freedom to explore digital libraries on their own terms.

3.4 Voice-to-text and audio search capabilities

Voice-to-text lets users talk to their library instead of typing – technology that converts spoken commands into text, enabling hands-free interaction with digital libraries. This approach feels like a miracle and is particularly useful for users with limited mobility, in addition to visual impairments. Google Voice Typing, Google Speech Services, Google’s Voice Search, Apple Siri, Microsoft Azure Speech Services, and Dragon Naturally Speaking are perfect examples of these types of tools, which allow users to search for books, input queries, or navigate interfaces using simple voice commands [15]. For example, a user can say, “Find a mystery novel” or “Books by Jane Austen,” and voice-to-text systems will transcribe the query for processing by the library search engine.

Audio search takes voice-to-text a step further by delivering results you can hear. Audio search enhances accessibility by eliminating the need for tactile or visual input, making it ideal for users with multiple disabilities. Typing can be difficult for blind users, so voice-controlled search is a game-changer. This technology relies on speech recognition and natural language processing (NLP) to interpret queries, with results delivered audibly to locate content based on verbal queries, making navigation more intuitive. The BARD Mobile application, Amazon Alexa, Apple Siri, and Microsoft’s Cortana already support such features and let users speak a book title, author, or even a keyword and hear the results read back – no screen needed [13]. Audio search capabilities also allow users to query digital libraries using spoken commands, making the library feel like a conversation rather than a task.

3.5 AI assistants and AI-enabled chatbots: Your library guide

AI assistants, such as Siri, Alexa, and Google Assistant, and AI-enabled chatbots like Be My Eyes virtual volunteer, provide conversational interfaces for accessing digital library content and act as virtual librarians, always available 24/7. These tools use NLP to understand user queries and can answer questions, recommend books, or even describe images in a book for you in audio format [16]. It is like a friend who knows the library inside out, ready to help whenever you need it. For example, Be My Eyes connects users to sighted volunteers or AI-driven descriptions of visual content, while the Alexa Royal National Institute of Blind People (RNIB) Talking Books skill allows users to access audiobooks via simple voice commands [25].

Technology	Feature	Benefit for visually impaired users
Refreshable Braille displays	Real-time tactile text output	Portable Braille access
DAISY format	Structured multimedia content	Chapter-level navigation
Text-to-speech engines	Synthetic natural speech	Audio access to textual content
Voice-activated search	Natural language queries	Hands-free library navigation
AI chatbots	Personalized assistance	Real-time help and recommendations

Table 2.
Technologies in digital libraries for the blind – features and benefits.

AI-powered chatbots can guide users through library catalogs, recommend books, or troubleshoot device issues, enhancing user independence, and can be embedded in digital library portals for voice-guided information retrieval [17]. Thus, integrating AI chatbots into digital libraries enables blind users to receive help in real-time, whether locating a book, getting research tips, or receiving personalized recommendations (**Table 2**).

4. Creating a DLB using Greenstone digital library software

Greenstone Digital Library Software (GSDL), developed by the New Zealand Digital Library Project at the University of Waikato, is a robust, free, and open-source software suite ideal for institutions looking to build and distribute digital library collections with limited resources [18, 19]. Its flexible customization, multilingual content accessibility, and metadata harvesting features make it like a blank canvas and a perfectly viable choice for creating a DLB, though enhancements are needed to fully support specialized formats and assistive technologies.

4.1 Features of GSDL supporting DLBs

GSDL offers several features that align with the needs of a digital library. Some of its current features that would be helpful for creating a digital library for blind users include the following:

4.1.1 Multilingual and unicode support

GSDL supports content in multiple languages, which is beneficial for serving diverse populations. It can host materials in English, Spanish, and other languages, aligning with the needs of global users, so a library can offer global reach and serve blind readers of varied languages [18, 19].

4.1.2 Metadata-driven smart organization

GSDL uses metadata to organize and index content, enabling efficient searching and navigation. This is essential for accessibility features like assigning headings, tags, or voice queries for categorizing Braille, audio titles, and large print materials. This allows advanced Metadata based navigation suitable for screen readers, allowing users to quickly search e-content and apply filters [18, 19].

4.1.3 Web and offline accessibility

GSDL collections can be published and accessed online or distributed on removable media like USB drives or any other portable storage drives, ensuring access for users without reliable internet connections. This is particularly valuable in developing regions where connectivity may be limited [18, 19].

4.1.4 Customizable design

GSDL allows customization of user interfaces, which can be tweaked to support screen readers like JAWS or NVDA, ensuring that users with visual impairments can access the digital library with ease and navigate to their desired information [20]. Its text-only interface can be adapted for screen readers or braille displays, improving navigation for visually impaired users [21]. GSDL offers a web-based interface as well, which can be customized as per the needs of blind users and enhanced for better accessibility and easy navigation. Greenstone's web interface works well with tools like large fonts or speech synthesizers, making it more accessible for visually impaired users [22].

4.1.5 Open-source flexibility

As open-source software means anyone can add new features, GSDL can be modified to integrate Braille or audio formats like DAISY, XML-based navigation, and TTS capabilities, making it adaptable for blind users [18]. GSDL is licensed under the GNU General Public License, allowing full access to the source code to those who are capable enough to handle it, enabling modifications to enhance its functionality [23].

4.1.6 Plugin capability

The plugin system of GSDL is a flexible and powerful tool that makes it easier to build digital libraries, including ones designed for blind users. Plugins are like customizable building blocks that handle different types of files, ranging from PDFs, Word documents, images, or audio, by processing them, extracting text, and organizing metadata to make content searchable. These plugins work together like a team, passing files along until one can handle the job. Greenstone comes with many ready-to-use plugins, such as the HTML Plugin MP3 Plugin for web pages and audio files, respectively, but its real strength lies in how easy it is to create new plugins for unique needs [22].

4.2 Stepwise guide to develop a DLB using GSDL

Creating a DLB using GSDL software shall create wonders. These libraries will act as transformative tools that empower visually impaired users with ease of access to knowledge and a culture of learning and innovation. Below, **Figure 1** shows the detailed list of steps for creating a DLB, including content acquisition, metadata assignment, interface customization, plugin integration, hosting, and user training.

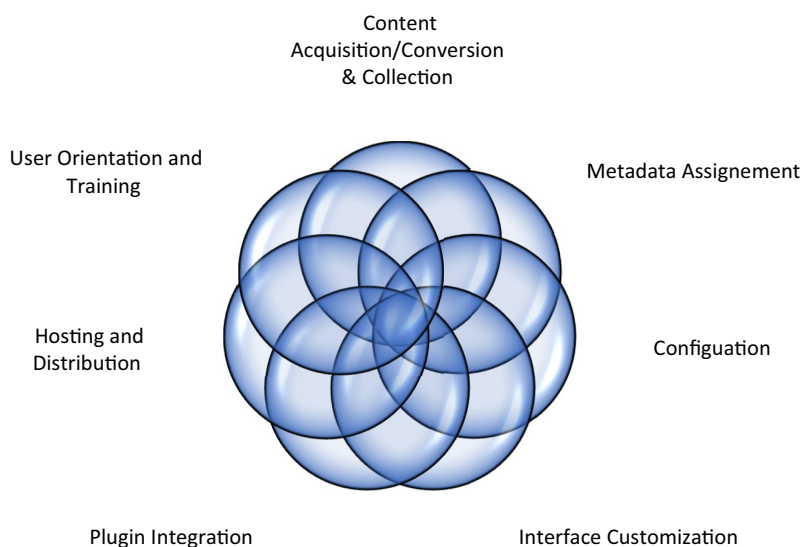


Figure 1.
 Workflow diagram showing the modules and step-by-step process for creating a digital library for the blind.

4.2.1 Content collection, acquisition, and conversion

Collection of materials for building the digital library is always the first step to be followed. When building a DLB, the content to be collected must be in accessible formats, such as DAISY, BRF, e-Pub, and MP3. Gather audio books, talking textbooks, and Braille-compatible e-Pub files. Import and categorize talking books and audio lectures, ensuring support for multiple formats (like DAISY, e-Pub, and Braille-ready files).

Available printed books can be converted into digital formats using OCR tools like ABBYY FineReader, and then structured in the DAISY format using tools like e-Clipse Writer [12]. Devices like the Blitab Tablet and the Canute 360 multiline braille e-reader, which deliver 360 cells of tactile output, enable page-level navigation of different formats of data, whether code, music, or even tabular data, which are absent from single-line displays [24].

4.2.2 Metadata assignment and configuration

While building the collection for a digital library, it is necessary to assign metadata elements to each item for its proper recognition and efficient retrieval. Assign detailed metadata elements like title, author, keywords, subject, format type (Braille, audio, etc.), accessibility type, and so on, to each item using GSDL's Greenstone Librarian Interface (GLI). Add alt-text, audio descriptions, and include tags to images, Braille, audio files, and large-print formats so users can filter what they need while searching and browsing the library.

4.2.3 Interface customization and plugin integration

GSDL's web interface can be modified to comply with Web Content Accessibility Guidelines (WCAG), ensuring it works with and creates compatibility with screen

readers and voice-activated systems. Customize the interface and make use of accessible HTML templates to make it compatible with screen readers.

Integrate plugins to enable audio playback, voice-based search, chatbot modules, TTS output, and voice command input. While GSDL does not have a specific plugin for DAISY files, however, a flexible plugin system can make it possible. Developers can create plugins to support accessible formats like DAISY or audio books, using the software's XML or audio plugins as a starting point. Plugins like the Paged Image Plugin can pull text from scanned books for screen readers, and audio plugins support spoken content, tailoring collection building to cater to blind users' needs [21].

4.2.4 Hosting and distribution

Host the library on a web server for online access, or distribute collections on USB drives for offline use. Ensure compatibility with devices like the VRS or Orbit Reader 20.

4.2.5 User orientation and training

Creating voice-guided tutorials and documentation makes the library feel welcoming. Provide proper training to staff and associated professionals, help blind users get started using the library, and provide proper guidance to users to search and navigate the library using assistive devices.

5. Proposed enhancements for GSDL

The GSDL provides a vigorous platform for building such libraries, with features like multilingual support and customizable interfaces. With tools like Braille, talking books, AI assistants, and a few other proposed upgrades and enhancements, GSDL would further position itself as a leading platform for developing advanced digital libraries, offering a robust, accessible, and user-friendly experience. These enhancements can mold GSDL into a powerhouse for blind users by blending human-centered design with cutting-edge technology. To enhance the capabilities of GSDL for creating advanced digital libraries and to make it future-ready and more inclusive, the following programs and AI-enabled systems can be integrated into it.

5.1 AI-driven TTS engine

Integrate an AI-powered voice assistant for natural language interaction. Using an AI text-to – speech engine like Google's Wave Net or Amazon Polly to turn any text into warm, lifelike audio for non-audiobook texts and generate summaries. This enhancement will create an advanced system where any content in the library can be read aloud instantly as inquired [15].

5.2 Voice-activated search module

Develop a voice-activated search module using NLP frameworks like Google's Dialog flow or Microsoft's Azure Speech Service. This would enable users to query the library using voice commands, with results delivered audibly, so users can ask for

books and hear results. This system can allow users to navigate the library with voice commands by simply saying, “Open the next chapter” or even “Read this page aloud,” and so on [13].

5.3 Smart chatbot integration

Embedding an AI chatbot and voice assistant tools like OpenAI’s Whisper, Google Assistant, and Be My Eyes virtual volunteer to guide and assist users with resource navigation, book recommendations, and fixing technical issues. The chatbot could use machine learning to personalize recommendations based on user preferences and enhance its capability to improve over time [16]. Machine learning is capable of generating alt-text automatically, classifying subjects without human intervention, predicting user preferences, shortening cataloging cycles, and surfacing relevant resources for blind patrons [26].

5.4 DAISY format support

Add native support for DAISY 2.02 and 3.0 formats, enabling seamless playback of structured audiobooks and eBraille files. Integrate with different Braille translation tools like “Lib Louis” to instantly convert digital information into Braille. These tools are usually used to automatically generate DAISY audiobooks from text-based documents.

Develop related plugins to parse Extensible Markup Language (XML) and Synchronized Multimedia Integration Language (SMIL) files to ensure full compatibility with devices like the Plectalk Pocket [12].

5.5 AI-enabled OCR and image descriptor

Incorporate AI-based OCR tools with advanced capabilities of describing an image, like those in Seeing AI, to convert scanned documents and describe images within books, making visual content more accessible and compatible formats. This would enhance access to visual content in educational materials [16]. OCR-to-Braille workflows combine scanners, ABBYY/Tesseract engines, and embosser queues to produce accessible copies of reserve readings [27, 28].

5.6 AI librarian or recommendation engine

Employ machine learning to recommend content based on user behavior, which allows real-time conversion of text-based documents into audio, thus enhancing accessibility to the library collection. A built-in assistant that answers queries and helps users search and interact more intuitively can suggest personalized reading material based on previous queries and interests of users. These AI librarians provide round-the-clock availability of ways and means of finding library resources across collections, freeing human librarians for complex queries [29].

5.7 Flexible access and navigation platform

Develop a flexible navigation system where users can navigate through multiple formats of information within a library. Provide a combination

of voice, touch, and Braille output, allowing users to switch between input methods and receive results that fit their needs seamlessly. This type of system allows users to speak their search queries instead of typing, and making use of NLP can make it possible to understand questions. For example, users could ask queries using voice commands on a smartphone or tactile input on a Braille display and receive results in audio or tactile output format [30].

6. Notable DLBs around the world

Several organizations across the globe have already started building amazing libraries to cater to the blind and print-disabled clientele. These libraries have proven their worth by providing unbelievable services, leveraging advanced technologies to offer accessible content, and lighting the way for blind readers. **Table 3** highlights different libraries across continents offering models of accessible service by leveraging advanced technology:

6.1 National Library Service (USA)

A subsection of the Library of Congress (LoC, USA), popularly known as the NLS for Blind and Print-disabled users, provides free Braille and talking book services, including over 100,000 titles in audio, Braille, and large-print formats. They also offer the BARD Mobile app for downloading books and magazines, as well as free digital players. These resources also support DAISY formats and voice-activated searches via Amazon’s Alexa voice assistant. DAISY, BARD Mobile (iOS/Android), XML, SMIL, digital cartridges, and RBD technology are incorporated to make this library more advanced and create a blind-friendly atmosphere [13].

6.2 Perkins library (USA)

The Library section of Perkins School for the Blind (USA) offers access to more than 250,000 titles in audio, Braille, large print, and audio-described DVDs. It provides access to over 500 newspapers via TTS, BARD access, and curated reading lists. These services are made available to users through DAISY, BARD Mobile, RBDs, and TTS systems [31].

Library	Location	Key features
National Library Service (NLS)	USA	100,000+ audio, Braille, and digital titles; BARD app; Alexa integration
Perkins Library	USA	Audio, Braille, large print; curated reading lists
RNIB Library	UK	AI search tools; voice commands
Sugamya Pustakalaya	India	Multilingual content; DAISY, ePub support
Bookshare	USA	1 million+ accessible titles; DAISY and screen reader support

Table 3.
Global exemplars of digital libraries for the blind.

6.3 RNIB library (UK)

UK-based library, popularly known as The RNIB Library, offers access to reading materials, including Braille, audio formats, and giant print books. It has integrated AI search tools like Amazon Alexa, enabling advanced access to digital content through voice commands [32].

6.4 Florida Bureau of Braille and Talking Book library (USA)

The largest U.S. library for visually impaired and print-disabled users has a collection of more than 2.4 million documents and 1.99 million annual Inter library loans. It offers Braille, audio, digital players, and large-print books. Advanced technology, such as DAISY, BARD, screen readers, and digital cartridges, is used to make information accessible to its users [33].

6.5 Braille Institute library (USA)

This library provides access to resources through Braille e-readers, audiobooks, and large-print books. They also offer podcasts, writing workshops, and a phone-based newspaper service. BARD, DAISY, TTS, Braille displays, VoiceOver technology is incorporated to offer the best possible services to its users with ease of access. The library is based in Los Angeles, United States of America [34].

6.6 DAISY consortium

A network of global organizations promotes the development of structured digital content and talking books. The DAISY format allows blind users to navigate and access digital text in their accessible format with ease [35].

6.7 Bookshare (USA)

Operated by Benetech, Bookshare offers over a million titles in accessible formats, including Braille, audio, and large print. It has developed a user-friendly interface and is integrated with multiple reading tools to provide access to its resources on multiple platforms. It uses DAISY standards and works with screen readers [36, 37].

6.8 Sugamya Pustakalaya (India)

An initiative by the Government of India and managed by the DAISY Consortium, this library aggregates books from multiple partners and offers them in accessible formats. It provides multilingual access to its resources, including Hindi, English, and other regional languages. The library supports various formats like DAISY, ePub, and audio [38, 39].

6.9 Connecticut Library for Accessible Books (USA)

Connecticut library for accessible books (CT LAB) provides access to more than 130,000 audio and Braille books in DAISY format, along with the BARD Mobile

application for accessing these resources. They also provide free digital players and support mail delivery and download options for online users [40].

6.10 New Jersey State Library Talking Book and Braille Center (USA)

New Jersey state library talking book and Braille center (TBBC), US-based library, offers audiobooks, Braille books, and large-print materials. They also organize different programs for the training of professionals who provide services to these types of users, like the LEAP program for teaching accessibility features on iOS devices. The library uses DAISY, BARD Mobile, and VoiceOver to output its resources for their users [41].

6.11 Indiana Talking Book and Braille library (USA)

Library dedicated to the visually impaired and print-disabled users offers access to Braille, audio, large-print books, and newspaper access via TTS. Besides, it offers summer reading programs to its users [42].

6.12 Delhi University Braille library (India)

More than 3,000 e-publications, DAISY workstations, Braille embossers; community volunteers record textbooks, demonstrating low-cost content generation at scale [43].

6.13 Vision Australia library

This library provides access to digital DAISY books, magazines, and podcasts. It has incorporated AI-based cataloging and reading tools to make the information accessible to users without human intervention [44].

6.14 Canadian National Institute for the Blind (CNIB) library

The Canadian National Institute for the Blind (CNIB) library offers accessible e-texts, Braille files, and TTS services. They have hosted their resources on a cloud-based infrastructure to ensure wide accessibility [45].

6.15 Tiflolibros (Argentina)

The library, based in Argentina, offers resources in the Spanish language. This library provides access to thousands of Braille books [46].

7. Discussion

The reviewed literature consistently highlights that technology alone is insufficient without a human-centered approach emphasizing usability, customization, and inclusivity [11, 18]. Emerging AI capabilities hold promise in overcoming longstanding barriers, such as navigation complexity and content description. Open-source solutions like GSDL allow scalable, customizable platforms

but require ongoing enhancements aligned with accessibility standards to fully serve the blind community.

Accessibility laws and international treaties underscore the imperative for inclusive design. The evolving digital library ecosystem for visually impaired users is a paradigm of how empathy, technology, and policy intersect to empower marginalized communities. This chapter integrates these insights to present a holistic view of DLBs, advocating for continuous innovation, collaboration, and policy support to ensure universal access to knowledge.

8. Conclusion

The creation and development of robust global policy for information access, growing accessibility standards, and rapidly advancing assistive technologies create a momentous window to bridge the “accessibility gap” of information that has existed for a very long time. Libraries that are enriched with inclusive design – from the procurement or digitization of information sources to service delivery as regular practice – place themselves at the vanguard of social innovation and intellectual equity. However, beyond the technology, there is a higher obligation to equity, empowerment, and the right to information and knowledge for all. Digital libraries can fulfill their democratic obligation only when their clientele with visual impairments and print disabilities can independently navigate, access, and comprehend the same corpus of information available to sighted readers. Building a truly accessible DLB is not all about technology; it is about empowering its users with a corpus of knowledge and opening doors to ideas, innovations, and opportunities. A DLB is not a matter of retrofitting the present system; it is about designing a tailor-made practice from the ground up.

By leveraging various tools and technologies like Braille books, advanced Braille-enabled touch screens, talking books, audiobooks, voice-to-text, audio search, and AI-enabled chatbots and assistants, we can create systems that shall break down barriers to information access and ensure inclusivity. GSDL shall be used as a prodigious platform to start from, and with a few smart enhancements like AI search capability, Braille support, and AI-enabled chatbots, it could develop libraries that feel personal and empowering. The best part of the scene is that many of these solutions already exist; thus, it is just a matter of setting them in an organized and right way.

Globally existing libraries such as the NLS (USA), Perkins Library (USA), RNIB (UK), and Tiflolibros (Argentina), among others, demonstrate best practices by developing admirable models for implementation with diverse formats of information and state-of-the-art technologies. By learning from these leaders in the field, adopting and enhancing already available tools, and implementing advanced features like AI-enabled audio search and results systems and chatbots, we can further improve these libraries. Furthermore, with advancements in artificial intelligence technology, these libraries will continue to progress in terms of accessibility for print-disabled and visually impaired users. Every step toward the development of technology brings us closer to a world where knowledge knows no boundaries and every single reader discovers a congenial home in the library.

List of abbreviations and acronyms

ADA	American Disability Act
BARD	Braille and audio reading download
BRF	Braille readable format
CD	Compact Disk
CNIB	Canadian National Institute for the Blind
DAISY	Digital Accessible Information System
DL	Digital library
DLB	Digital library for blind
DRM	Digital rights management
GLI	Greenstone librarian Interface
GPL	General Public Licence
GSDL	Greenstone Digital Library
HTML	Hypertext mark-up language
JAWS	Job access with speech
NAB	National Association for Blind
NLP	Natural language processing
NLS	National Library Services
PIP	Paged image plugin
RBD	Refreshable Braille display
RNIBP	Royal National Institute of Blind and Print Disabled
SMIL	Synchronized multimedia integration language
TTS	Text to speech
UDL	Universal design for learning
USB	Universal serial bus
VI	Visually impaired
VRS	Vector reader stream
WAI	Web accessibility initiative
WCAG	Web content accessibility guidelines

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Chapter 7

Perspectives on Rights: Issues of Information Access, Use and Discovery

Julie Griffin

Abstract

The digital library community must respond appropriately to the needs of user communities, as well as accordingly to the factors influencing information access and curation. Some of the questions addressed in this chapter, with reference to relevant initiatives and activities, include: what are the efforts of producers to make information accessible to all users?; what is the extent to which users are aware of (1) their rights to access information made available by some information producers (e.g., public access), and (2) efforts to promote equitable access to information (e.g., open access)?; and what is the extent to which users are aware of (1) the ways in which their privacy is protected by professional practice, and (2) the rights (and means) that are exercised by copyright holders in the pursuit of knowledge to maximize the ethical sharing and use of published literature?

Keywords: scholarly communications, library collections, open access, digital libraries, copyrights

1. Introduction

Recent efforts to expand access to information build upon the foundation of information organization and open movements toward a more connected scholarly information ecosystem. The information infrastructure that enables networked scholarship is complex, as are the forms of scholarship they support [1], and the conversations about the peer structures that recognize and incentivize new forms of scholarship [2, 3]. And while there exist open repositories with persistent links to full text for the outputs, or publications, resulting from these scholarly activities, in some cases because of requirements for public access [4, 5], studies have shown that, among academic faculty, databases continue to be the most frequently used information source for access to scholarly literature [6 p.183]. These publications, or works, adhere to traditional publishing practices as well as new requirements that enable publishers to facilitate Open Access (OA) and to allow for information exchange and interoperability. The requirements may include assignment of a Creative Commons (CC) license [7], standards for description (e.g., identifiers, acknowledgments), standards for research ethics (e.g., attribution), methodology

(e.g., reproducibility) and publishing on the web (e.g., repository archiving). The completed individual product may take the form of a dataset, article, book, book chapter, or conference paper indexed in a commercially licensed database and/or a publicly accessible repository or digital library. The metadata about these items may be available in commercial search engines, non-commercial databases of OA literature, and platforms for open research, all of which are the result of movements to make discoverable, and – in the case of OA – to make scholarly literature freely accessible to all. A sampling of the published literature on international and US efforts to encourage OA, an alternative to closed or subscription-based access, includes Willinsky's chapter on how open access became a norm in scholarly communications [8], and Nosek et al.'s article to the scientific research community on ways to advance science with more open practices [3]. Presented in this chapter from the author's perspective, will be a review of the issues just described, as well as the methods of access made possible by authors and managers of collections and how this access is situated within regulatory environments.

2. Information access

Managing, organizing, and providing access to the world's knowledge is core to what libraries do. Only within the last two decades or so has OA introduced a way of providing unrestricted access to this knowledge, a way further described by Peter Suber in his newsletter entry providing and explaining OA definitions, including the definition drafted at the 2002 Budapest Open Access Initiative [9, 10]. The methods employed by a library for supporting OA depend on the goals and priorities of the overarching institution, and the resources committed to the work of making, in the case of academic libraries – institutional scholarship – open access. It is important to remember that open is not the only means of access to scholarly literature, nor is fully OA the only way to make work open. The options for access are digital library systems that information professionals manage, and content that publishers and authors produce and distribute – ethically and legally – for use to advance knowledge. The responsibility for curating this content so that it can be accessed over the long term is shared by stakeholders across information environments. Information standards support this curation, including the effective curation of digital objects at each phase of the research and the scholarly communication process.

2.1 Open repositories

For many academic libraries, OA services include open repositories of grey literature, or scholarly works that have not been, or will not be, published by a commercial, society, or academic publisher. Often in the form of, for example, working paper series, technical reports, conference proceedings, electronic theses and dissertations (ETDs), preprints, and post-prints, these scholarly works are stored and archived in a system that operates curation services on the content for the purpose of long-term access and preservation. The privacy concerns of authors of these digital objects are presumed to be addressed by the choice provided, unless an OA mandate is in place, to opt-in or opt-out of repository deposit, which is understood to be immediate unless, for example, an embargo period is requested by

a student author of a dissertation from which a portion of the work will be commercially published. Though the default for institutional repositories (IR) may be open, metadata that describes the access levels and user rights granted for a digital object communicates parameters set by the author in this regard. The issues of rights for works published in IR archives are addressed in the later section on copyright.

Also contributing to the volume of openly available works are public access policies at the federal level. Policies in the United States, such as the 2022 Office of Science and Technology Policy (OSTP) Memo described in Bullock's article on the memo's implications for libraries, mandate that authors of publications supported by federal research grants provide access to their work in an agency approved repository as soon as a work is published [4, 5]. Reflected in the policies are usually networked authorship practices that increase readership and impact. Scholars within and outside of areas of research traditionally awarded external funding experience the continuously changing expectations for authors on the use of publishing innovations to maximize impact and optimize sharing. In effect, everyone is affected by the reasons for public access policies that represent a broadly applicable call for accountability, information, and a return on investments in scientific research. The groups affected include some publishers who comply with the policies by encouraging or requiring deposit in the publisher's open repository, or an externally hosted archiving service. Although federal agency public access in the United States began with the 2008 National Institute of Health Public Access Policy [[8] p. 42, 11], most of the studies of the impact of open practices focus on the impact of OA works, including the article by Piwowar et al. offering evidence of increased citation rates [11]. It follows then, if we are to extrapolate on the results, that an argument could be made, and Piwowar et al. offers this as well in reference to a 2010 study on the effect of funder information policy requirements, that both OA and public access (which also includes open repositories hosted by federal agencies) contribute to increased readership and impact of scientific literature, with the caveat, as Piwowar's 2018 study suggests, that OA by way of repositories is not a large portion of the overall OA literature [11]. In the United States, the decision to exclude from compliance requirements the federal agencies that sponsor research with publishing restrictions serves as an example of the security and/or privacy considerations given to policies developed on public access.

2.2 Published scholarly literature

In an academic setting, the writing process for a community of scholars requires access to published literature. Libraries provide this access by way of licensed and purchased resources made available to users in print and electronic formats, and, depending on a user's needs and campus location, the materials are accessed onsite from a library's physical holdings, delivered to a user, or accessed digitally over the internet. In recent years, issues having to do with subsidizing the costs of providing access to journals have presented a set of concerns that the information community calls the "serials crisis", as described by Lynch [12] in his article explaining the factors that were influencing the changes occurring in library services and operations in the early 90s. The open and public access pathways to scholarly literature have changed both scholarly publishing and library services. While core services for libraries remain the same, a few of the changes that have occurred within libraries most relevant to the subject of this chapter include an increase in OA

support, and increased involvement in the scholarly process, including the publishing of open educational resources (OER) [13]. Though there a correlation is unlikely, it is worth mentioning that publisher innovations in acquisitions processes for electronic books (e-books) have also changed to allow for more decision making that involves user input (e.g., user-driven, demand-driven, and evidence-based acquisitions).

For journals, publishers may use a variety of business models to subsidize the costs of production for fully or hybrid OA, a practice that Suber explains is necessary to cover costs for OA [14]. Some of the business models that are utilized by publishers to subsidize production include library subscriptions, sponsorships, and “institutional subsidies” [15]. Thatcher describes a strategy, which is discussed again in Section 3.2, that was introduced around the same time as OA publishing to encourage greater awareness among authors of their rights as copyright holders, and that involved utilizing resources developed to assist with author-publisher rights retention negotiations [16]. Over time, it could be argued, more authors of both OA and paywalled works have become interested in the terms of publisher agreements that make explicit the copyrights held by the author and granted to the publisher, for example, the right of the publisher to grant sub-licenses to third parties for content use and reuse [17 pp. 62–63]. Discussed later in the chapter is the move taken by some publishers of OA journals to apply CC licenses to increase transparency of copyright information for a publication, including the rights granted by the author to the publisher and to prospective users of the copyrighted material. A possible additional direction for conversations on reuse of content in databases or digital libraries, may be the processes available to authors for understanding the transactions involving their work.

2.3 Access strategy

Some universities adopt OA statements or policies to advance goals to increase the dissemination of research results. While the funder policies just discussed are about sharing requirements, institutional policies are about the rights of authors, and both increase access to the results of scholarship. Commercial publishers of hybrid OA journals offer authors the choice to publish openly. Publishers that do so may require authors to pay an article processing charge (APC) to cover the cost of production. Other publishers may allow libraries to provide APC discounts to authors as part of a “read and publish” agreement, described by Hinchliffe [18], as a license that also provides an institution with access to subscription-based content. Some research libraries may provide OA repository services, as previously mentioned, and/or publishing funds, as described in McMillan et al.’s article on a library’s experience with an APC funding program [19] used to offset the charges to authors for publishing in open access journals. To make such a service sustainable, libraries serving funds to authors for the purpose of OA publishing may introduce criteria for eligibility, including a journal publisher’s membership in the Open Access Scholarly Publishers Association (OASPA) [19, 20]. The availability of, and access to, services like an OA publishing fund may contribute to whether an author chooses to publish in an OA journal that charges a fee. Institutional OA policies influence decisions as well, as do peer practices and expectations for promotion and tenure. To meet the demand for support, libraries must understand the OA policy landscape and publisher OA business models, and

at times consider investing in OA, whether covering per article fees, signing “read and publish” agreements [18], or joining a membership-based OA initiative, to meet organizational goals for OA.

3. Regulatory environment

In the United States, protecting the intellectual property of the author of a copyrighted work is copyright law, or USC Title 17 [21], and, in academic settings, various rights make access to copyrighted scholarly literature possible for prospective users of information. For authors and information users within the academy, understanding and managing these rights may be difficult without support from publishers, libraries, and groups concerned with the legal environment within which the process of communicating scholarship is situated. And engaging with copyright are multiple information stakeholders. Published authors or authors publishing may be interested in understanding what their rights are and how to exercise these rights as copyright holders. Users of information may be interested in understanding how to respect the rights of copyright holders while also leveraging exceptions to restrictions on the use of copyrighted materials. Libraries may be interested in understanding how to interpret and comply with copyright law in the various service areas that libraries and the community members they support work with copyrighted materials.

3.1 Rights and copyrights

Efforts to assist with copyright are an important aspect of regulatory environments. For an institution engaged in representing the interests of its scholarly community in content licensing negotiations, for example, support may be provided to the library by a Legal Office or Counsel. Rights may be negotiated in these access negotiations toward a “transformative agreement” that, as Hinchliffe explains, would also provide licensed access and facilitate the potential sharing of an institution’s authors’ work as open access [18]. Communities of library professionals working with copyright and licensing issues offer resources on best practices, online forums for discussion, and courses taught by experts in copyright law and library and information science (LIS) professional associations. Academic libraries in the United States may provide guidance on “fair use” [22] to community members interested in using copyrighted works while also protecting the rights of copyright holders and reducing the risk of infringement [17 pp. 62–63]. Libraries working as consortia may also share resources [12] and legal support in contract negotiations.

Privacy issues in this context involve two disparate aspects of work with collections, the first is an information access concern having to do with publisher non-disclosure requirements, and the second is a patron privacy issue when it comes to the use of library acquired and managed resources. The reasons for these privacy concerns are quite different. Privacy is a concern for publishers as it pertains to disclosing the details of a negotiation. The goal for the publisher is to offer competitive pricing, which includes calculating cost based on institution-specific data points. For libraries, the concern is negotiating for the best possible pricing for their institutions, and they do so by balancing financial constraints with resource needs and collection policy. While patron privacy is discussed in a later section, it is

important to mention with this discussion of content access that, in the United States, consideration is always given in license negotiations to the privacy concerns of library users, as described in the American Libraries Association (ALA) Code of Ethics that promotes the ethical and responsible stewardship of library resources, and the processes involved in acquiring, managing, and providing access to library resources [23].

3.2 Rights management

An author's engagement with copyright is also important for publishing integrity. Considerable efforts to advocate for authors have made it possible for them, as copyright holders, to share their work with others, as affirmed by Willinsky and Hansen [8 pp. 32–33] [24]. According to Willinsky, the effect of groups advocating for and promoting alternative publishing models began to take hold in 2003 [25 p.1], when methods were introduced, for better or worse according to Thatcher, to balance the rights of copyright holders with those of the publisher, encouraging authors to retain control over their published work, whether the work is communicated OA (e.g., open access journals) or in traditional publishing models (paywalled, closed, or subscription-based access) [16]. While the copyright held by publishers and authors may be based on separate concerns, and establishing a direct correlation may be difficult, the open and public access movements that seek to increase access for those who would not otherwise have it may have influenced a trend in publisher copyright policies toward allowing author deposits of pre- and/or post-prints in repositories. To assist with interpreting these policies, a response from the information community was to develop resources to offer guidance, such as Jisc's "Open Policy Finder" [26], which Selman et al. describe in their paper on copyrights and OA [27]. It is this effort taken by authors to utilize resources to understand the rights they retain in publisher policy and the rights for which they would need to negotiate that offers them agency in the publishing process. Also contributing are efforts by publishers to institute rights management methods, such as CC licenses, that increase transparency in the transfer of an author's rights and in the author's control over how their work is used.

The IR service is concerned with the rights of authors to deposit and openly share their copyrighted works. These are granted for grey literature during the submission process, however, for published works, journal articles for example, the author becomes responsible for ensuring their copyright agreement with a publisher does not conflict with the non-exclusive rights that must be granted for IR deposit. The author addendum referred to by Thatcher [16] may assist an author with negotiating for rights after a manuscript is accepted, or a publisher's policy may allow for deposit of certain versions of a work, perhaps even the publisher formatted PDF, for works with an agreement already in place. As previously mentioned, OA policies allow for more author control over sharing, or self-archiving and using their published work for teaching and research. An OA policy may, depending on the terms, also encourage authors to deposit to an IR or open repository.

3.3 Use of information

Digital libraries, which may describe a service or underlie a proprietary database or a repository system, assist users with searching and finding information. Fox et al.

describe the extent to which digital libraries are involved in many of the ways we engage with information [28 p. 1]. Efforts to increase access to materials in digital libraries have been underway for some time and include building digital collections and structuring information for machine readability and improved discovery. Information in library catalogs is structured in MARC (Machine-Readable Cataloging) format [12]. Information in open repositories may be structured using metadata standards such as Dublin Core [29], and the structured information is used by digital services to curate content based on applicable policies. Structuring information based on standards like these is crucial for a digital library to be functional and effective.

In addition to supporting use for information search, retrieval, and curation, the digital library community is also aware of the need to structure information for discovery, use, and reuse. The information community supports and encourages each other in these endeavors, as do the producers of information, who also share responsibility for preparing information for exchange across systems. For authors preparing materials for deposit to a repository, for example, the adoption of new practices that support use and reuse may need to be incentivized. It helps to understand why authors take on new practices, a topic that Yang and Li have explored to inform repository services and outreach [30]. The same is true for new practices in digital library development, whether the digital library is an open repository or a discovery service. An example is the paper by Van De Sompel [31] on a conceptual model for distributed publishing workflows, which conveys how important sustained engagement with a technology is to its widespread adoption. Information producers, such as publishers of commercial databases, are also responsible for preparing information for access and use, which they do based on applicable standards and best practices.

4. Library collections

Today, the LIS standards in academic libraries for excellence in the provision of access to purchased, licensed, and open access collections draw upon professional standards such as ALA's Code of Ethics in the United States [23], as well as IT security protocols, and the application of best practices in research integrity. The application of these standards cuts across all aspects of work in the academy. IT infrastructures must meet standards for security and stability, and also allow for change management and experimentation. Standards and protocols must also be applied to electronic information for it to be used effectively in digital libraries. Usually, these standards and protocols are developed and introduced by publishers as well as the information community, as previously mentioned, alongside efforts to establish practices at the local level. And, lastly, as previously mentioned, patron privacy considerations are given to all aspects of work with library collections. The result is a well-managed and seamlessly accessed collection of library resources.

4.1 Libraries and publishers

Information, including some factual data, made available in proprietary or commercial databases, is protected by copyright law [32]. Access to these resources is provided through a library's discovery service and made available through

a library's subscriptions and purchase agreements. A library's Library Services Platform (LSP) is curated to maintain current information about the list of resources available to library users. Access is provided to licensed resources for research purposes on a case-by-case basis by way of a conversation between publisher, library, legal counsel, and researcher, and sometimes the answer to a request for access is that granting "text and data mining" rights is not allowable [[17] pp. 61–62]. Depending on the content of interest to a researcher, open digital libraries may be a less cumbersome option for a source of data, though the cost to IR managers and IR users becomes apparent when issues arise with statistical accuracy and the amount of time a system cannot be reached due to periods of unusually heavy traffic. Perhaps more importantly is the opportunity such requests present for a conversation with researchers about text and data mining, as well as data science, machine learning and artificial intelligence. Library support for projects that involve applying new technologies to large corpora of data is work that may rest with a team of individuals in academic libraries. The expertise it draws upon may include "business and legal practices" as suggested by Cross et al., collection management, copyright [33 p. 72], and – I would argue – data analytics or data science, and subject expertise.

Publishers, in addition to libraries, adopt standards, protocols, and participate in scholarly communication initiatives focused on OA and research integrity. This includes their decision to assign CC licenses to works, as previously mentioned, and to request or require Contributor Role Taxonomy (CRediT) metadata [34] and researcher identifiers such as ORCIDs [35]. Influencing author choices are also an institution's and/or library's choice to participate in publishing initiatives that encourage creative and collaborative ways of enabling access to scholarship. As these creative strategies for knowledge sharing are explored, libraries continue to acquire and manage access to content for their institutions and/or communities. A lot has changed in how libraries engage with content and bibliographic information, and how publishers, information consumers, scholars and researchers, and research institutions engage with this same information.

4.2 Discovery services

There are many protocols, or standardized practices, in place that suggest how individuals in a community of practice engage with one another. Some may be contractual obligations, and some may be invitations to participate in an activity guided by an established set of rules. Privacy concerns arise when these frameworks or conventions may not be in place or may not be enacted. Our digital networked environments can also expose the vulnerabilities of a system to exploitation. The library community must rely on professional standards and codes of ethics to guide decision making when responding to service requests that introduce innovative technologies and new technology-enabled practices. It is important to remember that privacy challenges also apply to working with sensitive information within the library [36 p. 299]. Librarians providing information services may consult a variety of policies, standards, and best practices, some of which have already been mentioned, and include: (1) institutional policies that offer guidance on complying with requirements for information security; (2) library professional standards on patron privacy; (3) institutional policies on intellectual property; (4) applicable laws on copyright; and (5) research protocols.

Thankfully, conventions are in place for the exchange of information across systems that may include open and proprietary discovery services and databases and repositories of metadata and full text. However, these protocols may be taken a step further when, for example, the infrequent harvesting of metadata for indexing purposes expands to include more frequent mining of metadata and full text for machine learning purposes. And when this occurs, there may be concerns introduced about use and algorithmic bias. A consideration for IR managers of collections in the future is what information to suggest authors include with deposits, bearing in mind that an item may be harvested without contextual information. Another consideration may be whether the advent of AI will introduce another conceptualization of OA resources that has not been thought of yet.

In terms of privacy concerns, open access may not immediately suggest “privacy” as the OA meaning of “open” implies public, and OA is a means of accessing scholarly works made possible by copyright holders, or authors, of the works. However, authors may hesitate to make research more open out of concern for whether at the local level application of standards are occurring within infrastructures in the environments where systems are managed. And so, it becomes critical, for individuals striving to successfully meet an institution’s goals for open science/research/access, that an institution provides support for secure infrastructure. While the information science community recognizes the importance of security in digital infrastructures [1], libraries engaging in this work within a much broader technology and governance environment may be challenging for many reasons, including competing demands or unintentional siloing of communities of practice.

5. Conclusion

The movements to increase access to scholarship, scholarly literature, scholarly works or scholarly outputs challenge the scholarly community to look more closely at the relationship between regulatory and information environments. A trend toward OA may result in competing demands for authors in a position to make decisions about whether to publish in a closed system or to adopt open practices, and for individuals responsible for managing and also legally and ethically providing access to collections of copyrighted materials. An effective means of addressing these concerns may be finding a way to reliably present, as much as possible as a choice to information producers, the prospective use cases for their work. Challenging this approach, however, is the automation of processes involved in the harvesting and reuse of electronic information. In summary, opening within the context of web technologies and data analytics adds a new dimension to conversations about privacy and responsibility in scholarly communications.

Developers of digital libraries and digital infrastructures are motivated by a need to comply with law and policy and an interest in successfully responding to user needs. Influencing the policies are the privacy and security concerns of the individuals working in these networked environments. What authors may experience due to these, and other influences, are digital library innovations that introduce options for publishing works OA and options for managing copyrights, as well as guidance for ethical authoring practices and complying with public access

requirements. Navigating this terrain while taking into consideration a much broader set of technical, legal and social concerns may continue to be a complicated process for information producers, users and professionals. It remains critical for libraries during this period of uncertainty to remain committed to their commitment to service excellence in the provision of access to information. Doing so will allow libraries to continue to meet the information needs of library users, as they support engagement in new practices informed by a careful approach to information experiences in technologically innovative environments.

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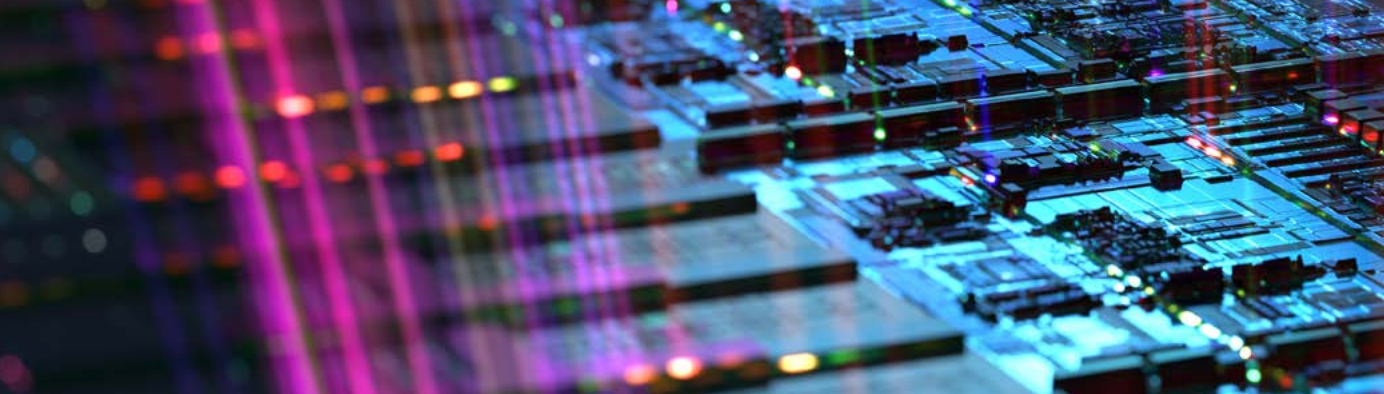
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Digital libraries are transforming the contemporary knowledge ecosystem, reshaping how information is created, shared, accessed, and preserved. Advances in digital technologies, networked infrastructures, and data-driven tools have expanded libraries beyond physical spaces and institutional boundaries, enabling new forms of scholarly communication, learning, and public engagement, while also introducing complex conceptual, technical, organizational, and ethical challenges. *Digital Library – Concepts, Challenges, and Future Directions* explores these transformations through contributions from diverse perspectives and global contexts. The volumes offer a balanced overview of foundational concepts, current challenges, emerging technologies, and the productive synergies shaping digital library development and use worldwide, reflecting the field's interdisciplinary and evolving nature. Covering topics such as digital library models and architectures, metadata and interoperability, digital preservation, user experience and accessibility, intellectual property and ethics, and the growing influence of artificial intelligence and data analytics, the book integrates theoretical insights with practical experiences drawn from a wide range of institutional and cultural settings. Authored by researchers and practitioners across disciplines, including library and information science and the digital humanities, this open-access volume underscores the global relevance of digital libraries and the importance of context-sensitive approaches. Its publication aligns with the principles of knowledge sharing and inclusivity central to digital libraries and IntechOpen's mission. Organized thematically from conceptual foundations to applied challenges and future-oriented perspectives, this book is also an essential resource for researchers, graduate students, librarians, and information professionals engaged in digital library research and practice.

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