

EXPLORING AI APPLICATIONS IN LIBRARIES: A TOPIC MODELLING ANALYSIS OF RECENT TRENDS AND THEMES

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Abstract: This study examines the application of Artificial Intelligence (AI) in the field of library and information science using a topic modelling approach. By applying Latent Dirichlet Allocation on the titles, abstracts, and keywords of articles indexed in Scopus, we identify the primary themes within AI-related library research. Seven key topics emerged from the analysis, covering themes such as AI for student and academic engagement in libraries, AI integration in business and education, smart library services and information technology, knowledge and data management, machine learning for detection and recognition, data-driven models and classification techniques, and AI in language processing and information analysis. These findings highlight current priorities and emerging trends in AI applications within libraries, revealing both the scope of ongoing research and potential future directions for AI-enhanced library services. This study provides valuable insights for researchers, practitioners, and policymakers seeking to leverage AI to advance library functions and services.

Keywords: Artificial Intelligence, Libraries, Topic Modelling, LDA, Library Science

Introduction

Research publications focused on artificial intelligence (AI) applications in libraries have expanded at an exponential rate in recent years (Hodonu-Wusu, 2024). As libraries worldwide adopt AI to support various functions—from enhancing user experience to improving information retrieval systems—the scholarly community has responded by investigating these advancements in depth. This surge in AI-related library research reflects both the rapid technological developments within the field and the transformative impact these tools are expected to have on library services (Borgohain, Bhardwaj & Verma, 2024). As a result, the academic discourse around AI in libraries has grown rich and diverse, encompassing a broad range of topics, methodologies, and areas of inquiry.

Despite this significant body of work, a clear understanding of the key themes emerging from AI-related library research remains elusive. With the diverse approaches and topics covered, pinpointing the central themes within this field is challenging. Scholars have explored varied aspects of AI in libraries, including digital literacy support, personalized recommendations, and predictive analytics for collection management (Kang, 2022; Chigwada, 2024; Mohod et al., 2024). However, there is currently no comprehensive analysis that organizes or synthesizes the predominant themes unifying these studies. This fragmentation leads to scattered insights across subdomains, making it difficult for both researchers and practitioners to grasp the current state of knowledge, identify gaps, or establish coherent research agendas.

The lack of thematic clarity has practical and scholarly consequences. For instance, library administrators looking to develop AI-driven services often face uncertainty about which technologies are most relevant to user engagement or resource optimization, due to inconsistencies in the way these themes are reported or emphasized across literature (Shahzad, Khan & Iqbal, 2024). Similarly, policy-makers attempting to craft guidelines for ethical AI use in libraries are challenged by the absence of consolidated evidence regarding key risks or success factors (Verma & Gupta, 2022). Without an organized thematic structure, emerging areas—such as AI in knowledge discovery or metadata automation—may be underrepresented, leading to imbalanced policy priorities and misaligned funding strategies.

This study aims to address this knowledge gap by systematically identifying the key themes emerging from AI-related research in the library domain. By applying text mining and topic modelling techniques, we analyse a substantial number of AI-focused publications to reveal the central topics and trends that have captured researchers' attention. This thematic analysis will provide a clearer picture of the main areas of interest, trends, and priorities within the field, helping scholars understand the trajectory of AI research in libraries. The significance of this study is considerable, as it provides a foundational understanding for both researchers and library practitioners. By distilling the complex body of AI literature into identifiable themes, this study offers a roadmap for future research and enables libraries to make informed decisions about AI adoption. Additionally, it will contribute to the broader understanding of how AI can serve library goals, enhance user experience, and support the evolving role of libraries in the digital age.

Literature Review

Text mining encompasses a wide range of techniques for processing and analyzing text, including methods such as sentiment analysis, named entity recognition, and summarization (Anton et al., 2020). These techniques aim to convert unstructured text into structured data by identifying and extracting patterns, such as common phrases, keywords, or sentiments. Text

mining provides the foundation for understanding large amounts of text by reducing noise and isolating useful information (Hassani et al., 2020).

Topic modeling falls within the scope of text mining and focuses specifically on discovering the underlying themes present in a document corpus (Churchill & Singh, 2022). Topic modeling is a technique used to discover themes or topics within a large collection of text documents. By analyzing the patterns of words that appear together across documents, it identifies recurring subjects, helping to organize and summarize large amounts of unstructured text data. There are many techniques available for conducting topic modeling, and one of the most widely used is Latent Dirichlet Allocation (LDA) (Vayansky & Kumar, 2020). LDA operates on the assumption that each document in a corpus is composed of a mixture of various topics, and each topic itself is characterized by a distribution over words (Chauhan & Shah, 2021). There are several tools that support LDA analysis, including Orange for visual programming, Gensim for Python-based NLP, and Mallet for efficient Java-based processing. R's topicmodels package and scikit-learn also provide LDA functions for users familiar with R and Python, respectively. For cloud-based solutions, Azure Machine Learning and IBM Watson Studio offer scalable options for large datasets (Liermann, 2021).

The use of LDA has become a widely adopted and highly regarded technique among researchers across various academic and professional fields. Its strength lies in its probabilistic modeling framework, which enables the automatic discovery of hidden thematic structures within large and often unstructured collections of text. By analyzing patterns in word co-occurrence across documents, LDA can effectively uncover latent topics that might not be immediately apparent through manual inspection. This capacity to distill complex and voluminous textual data into coherent themes makes LDA especially valuable in domains such as social sciences, healthcare, education, marketing, political discourse, and, increasingly, library and information science. Researchers utilize LDA not only to gain insights into public discourse and emerging trends but also to track conceptual developments over time, cluster similar documents, and support evidence-based decision-making.

One of the most appealing features of LDA is its flexibility and adaptability (Ma & Kim, 2023). It can be applied to diverse forms of text, ranging from academic literature and social media content to government reports and news archives. This versatility allows researchers to customize their analysis according to specific research questions, data types, and contextual needs. Furthermore, the outputs of LDA—such as keyword-based topic descriptions and document-topic distributions—provide interpretable and actionable results that support both exploratory and confirmatory analyses. As a result, LDA continues to serve as a foundational tool in text mining and topic modeling research, empowering scholars to transform large-scale textual corpora into meaningful thematic insights that drive academic inquiry, inform policy, and support practical applications across disciplines.

As shown in Table 1, a range of recent works have employed LDA to uncover hidden patterns and thematic structures within large textual datasets related to libraries and adjacent domains. These studies span various application domains—from digital infrastructure and metadata analysis to service optimization and scientometric mapping—demonstrating LDA's versatility as both a discovery and classification tool. For example, Litsey and Mauldin (2018) applied LDA to support predictive analytics in academic library planning, while Li et al. (2019) used the technique to examine thematic shifts in China's digital library landscape. More recent studies such as Panda and Kaur (2024) and Bhattacharya (2024) leveraged LDA to explore the

integration of natural language processing and AI within library services, focusing particularly on multilingual metadata and automation trends. Notably, Borgohain et al. (2024) conducted a dedicated scientometric review using LDA to surface dominant and underexplored themes in AI-related library research, offering a valuable overview of current knowledge gaps. These varied applications reveal that beyond its technical utility, LDA contributes conceptually by enabling researchers and practitioners to identify emerging trends, prioritize innovation areas, and enhance decision-making frameworks in library and information science. As such, this table serves as a reference point for understanding how topic modeling continues to evolve as a methodological asset in the field.

Table 1: Selected Past Study That Used LDA

Study	Application Domain	LDA Focus / Implementation	Intended Outcome
Litsey & Mauldin (2018)	Academic library planning and analytics	Applied LDA for pattern recognition in library decision data	Inform service design through predictive analytics
Li et al. (2019)	Digital library infrastructure in China	LDA used to identify evolving themes in big data libraries	Enhance scalability and modernization of digital collections
Enakrire & Smuts (2023)	Knowledge management in university libraries	Used LDA to map conceptual knowledge clusters	Improve knowledge-sharing systems in higher education libraries
Panda & Kaur (2024)	NLP and bibliometrics in academic libraries	LDA applied to explore multilingual metadata trends	Support inclusive access and bibliometric research
Bhattacharya (2024)	AI-driven modernization of library services	Used LDA to map technological trend shifts	Identify key innovations for personalized and automated services
Borgohain et al. (2024)	Scientometric analysis of AI in libraries	Core study on AI theme extraction using LDA topic modeling	Reveal dominant research clusters and thematic gaps
Mutia et al. (2024)	Academic libraries and AI-supported learning	LDA used to analyze student-library interaction patterns	Support curriculum-aligned AI integration in digital literacy development
Sivaraj et al. (2024)	Decision support and optimization in library ops	Used LDA to extract operational themes from service logs	Improve service workflows and resource allocation

Research Methodology

Figure 1 outlines the sequential steps followed in this study to implement LDA for topic labelling. The process begins with data collection from Scopus, followed by data pre-processing involving text cleaning, stop word removal, and tokenization to prepare the text for analysis. In the LDA labelling phase, a dictionary and corpus are constructed, the model is configured and trained, and topics are extracted and interpreted. Finally, the model coherence is evaluated to ensure the resulting topics are meaningful and logically grouped. The following provides the detailed description of each activity.

Data Collection

The dataset for this study was extracted from Scopus, a comprehensive database of peer-reviewed literature. To ensure that the articles selected were relevant to the field of Library and Information Science and focused on AI, we applied a search query with specific keywords. The search string used was: SUBJAREA (soci) (TITLE-ABS-KEY (library) AND TITLE-ABS-KEY (artificial AND intelligence)). This query limits results to the subject area “Social Sciences” (SUBJAREA soci), ensuring relevance to library and information sciences, and

retrieves articles that include the terms "library" and "artificial intelligence" in their titles, abstracts, or keywords. This query returned a total of 906 documents, covering a range of topics where AI intersects with library science.

Data Preprocessing

To prepare the dataset for topic labelling, the following preprocessing steps were conducted:

- Data Consolidation: Each document's title, abstract, and keywords were combined to create a single text entry, maximizing the available information for each article.
- Text Cleaning: The combined text entries were converted to lowercase to maintain consistency. Non-alphabetic characters, such as punctuation and special symbols, were removed to reduce noise in the data.
- Stop Words Removal: Commonly used words (e.g., "the," "and," "is") that do not add meaningful content were removed using a predefined list of English stop words.
- Tokenization and Stemming: Each document was tokenized, splitting it into individual words, and stemming was applied to reduce words to their root forms. This helped standardize variations of words (e.g., "libraries" and "library") into a single term.

LDA Topic Modeling

To identify the underlying themes within the dataset, LDA was employed as the topic labelling technique. The steps used were as follows:

- Corpus and Dictionary Creation: Using the preprocessed text data, a dictionary was created to map each unique word to a unique identifier. A corpus was then generated, representing each document as a bag-of-words vector based on the word counts in the dictionary.
- Model Configuration: The LDA model was configured to identify seven topics within the dataset, determined through experimentation and coherence scoring to ensure meaningful and interpretable topics. Before finalizing the seven-topic model, we tested models with topic counts ranging from five to fifteen. Each model was evaluated based on coherence score and human interpretability. Although coherence scores increased marginally for topic counts beyond seven, the clarity and distinction of the themes diminished. The seven-topic model provided the best balance between coherence and thematic differentiation, aligning well with the research objectives and the interpretability needs of library practitioners and researchers.
- Model Training: The LDA model was trained on the corpus using Gensim, a Python library for topic labelling. The training process involved iterating the model over the corpus multiple times to achieve stable results and refine the separation of topics.
- Topic Extraction and Interpretation: Once the model was trained, the top keywords associated with each topic were extracted. These keywords formed the basis for interpreting and labelling each topic according to its most representative terms.

Evaluation of Model Coherence

To ensure that the topics generated were coherent and meaningful, coherence scores were calculated. Coherence scores measure the degree to which the words in a topic make sense together, with higher scores indicating more interpretable topics (Lamirel, 2024). Based on the coherence results, five topics were selected as they provided an optimal balance between interpretability and coverage of the dataset's themes.

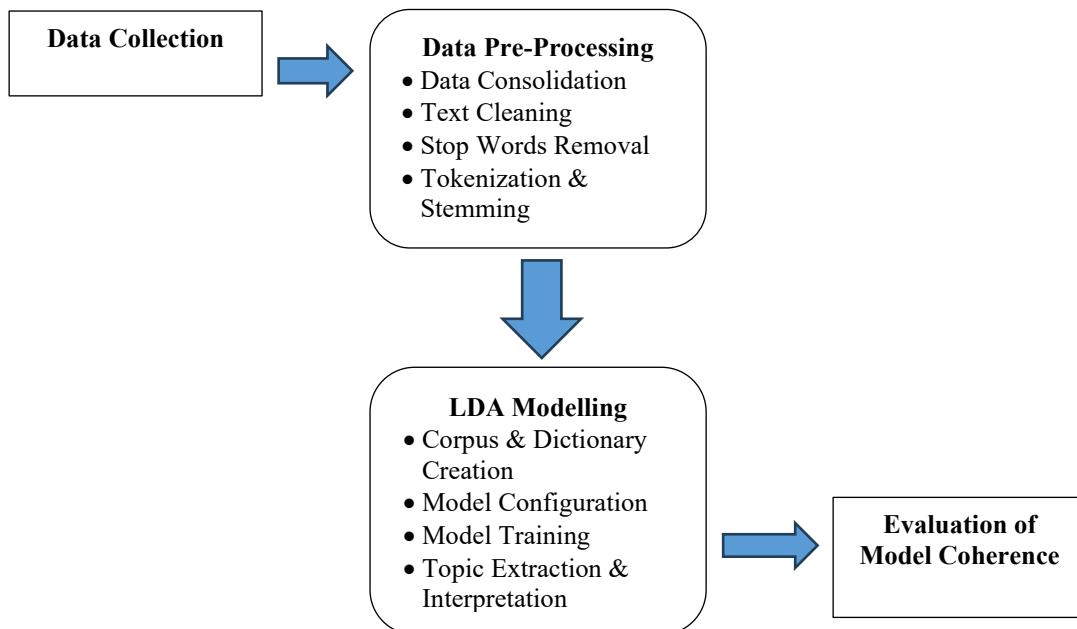


Figure 1: Sequential Steps of Research Methodology

(Source: Developed by the authors)

Findings

The thematic analysis of AI applications within library-related research reveals seven primary areas, each characterized by distinct trends in both technological applications and library practices. The analysis reflects an evolving landscape in which libraries are not only adapting to AI but also actively participating in its advancement, thereby reinforcing their relevance in a digitally-driven world.

Figure 2 illustrates the distribution of articles across seven identified themes related to AI applications in libraries. The themes vary significantly in the number of associated articles, highlighting areas of prominent focus and research interest. "Smart Library Services and Information Technology" and "AI in Language Processing and Information Analysis" have the highest representation, indicating strong interest in using AI to enhance library services and manage language-based resources. Conversely, "AI in Business and Education" shows fewer articles, suggesting it is a less explored theme within this dataset. Other themes, such as "Knowledge and Data Management in Libraries" and "Machine Learning for Detection and Recognition," exhibit moderate representation, reflecting steady interest in these areas.

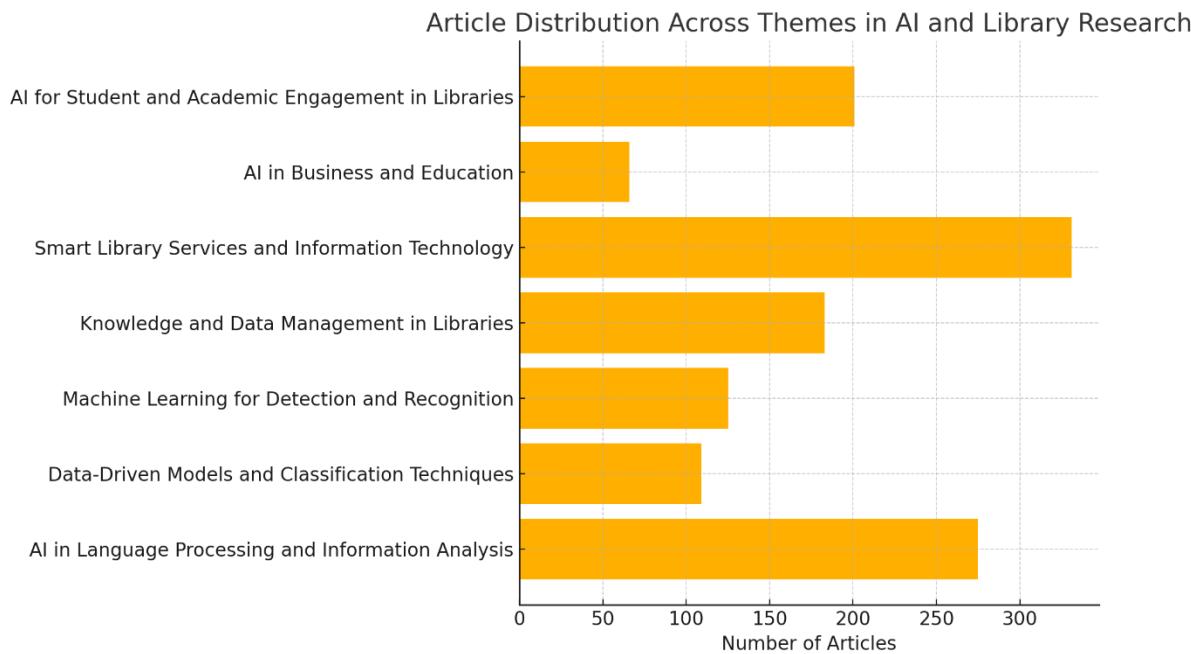


Figure 2: Article Distribution Across Themes
(Source: Processed by the authors)

Figure 3 provides a 2D visualization of the LDA topics using PCA for dimensionality reduction. Each point represents an article, color-coded according to its assigned topic. The distribution of points suggests distinct clusters for some topics, while others show more overlap, indicating varying degrees of thematic separation among the topics.

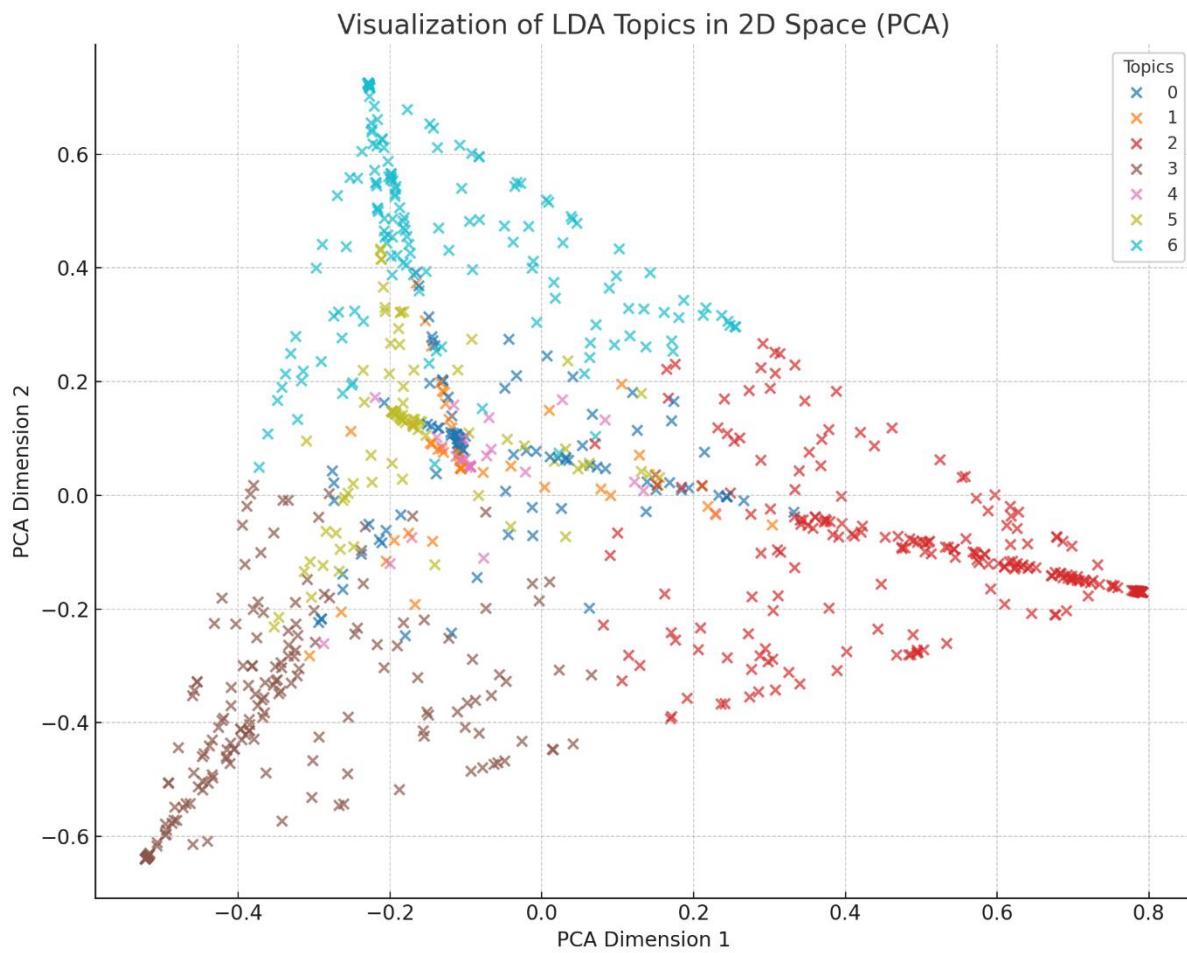


Figure 3: Thematic Clustering of LDA Topics in AI and Library Research (PCA Visualization)

(Source: Processed by the authors)

AI for Student and Academic Engagement in Libraries

This theme encompasses 201 articles and is characterized by keywords such as information, research, librarians, academic, library, study, intelligence, artificial, libraries, and AI. The findings indicate a clear trend toward enhancing AI literacy within libraries, particularly for students and academic staff. Libraries are shifting from traditional roles to AI-enriched environments, wherein librarians assume expanded roles as educators and co-creators of AI-driven resources. This shift supports an increasing demand for AI-driven educational tools that offer tailored support, prompting the development of competencies in AI literacy among both librarians and patrons.

AI in Business and Education

Comprising 66 articles and associated with keywords like approach, framework, digital, models, reasoning, learning, design, business, model, and based, this theme reflects the integration of AI into educational frameworks and business models within library contexts. A focus on digital literacy, inclusive design, and pragmatic pedagogical approaches underscores AI's role in broadening library services beyond traditional information provision. Presentations at academic conferences increasingly emphasize these aspects, pointing to a growing need for libraries to actively support educational processes through digitally inclusive and adaptable frameworks.

Smart Library Services and Information Technology

Involving 331 articles and marked by terms such as digital, AI, research, technology, services, artificial, information, intelligence, libraries, and library, this theme illustrates the library's transformation into a smart service provider. AI applications such as natural language processing, sentiment analysis, and tools like ChatGPT enhance the user experience, signifying a shift toward responsive, user-centered, AI-driven library services. However, limited adoption in some regions, particularly in developing countries, highlights the ongoing challenges related to infrastructure and professional training required to fully integrate these technologies.

Knowledge and Data Management in Libraries

Reflecting a trend where libraries are positioned as hubs for knowledge and data management, this theme includes 183 articles and keywords such as systems, artificial, digital, intelligence, science, knowledge, research, data, library, and information. Libraries increasingly play central roles in managing and organizing data, often intersecting with broader societal and disciplinary needs, such as in healthcare and Big Data applications. Through deploying AI tools for complex data handling, libraries support advanced knowledge dissemination and contribute to broader digital ecosystems.

Machine Learning for Detection and Recognition

This theme, supported by 125 articles and keywords including methods, models, analysis, used, model, data, using, based, machine, and learning, demonstrates the high-level, specialized applications of machine learning within libraries and adjacent fields. Real-world applications of machine learning, particularly in diagnostic contexts, underscore AI's potential for precise data verification, indexing, and categorization in libraries. Such applications highlight the expanding role of libraries in managing information accuracy, a critical aspect of maintaining trustworthiness in information dissemination.

Data-Driven Models and Classification Techniques

With 109 articles and keywords such as systems, artificial, library, computer, used, using, students, based, machine, and learning, this theme captures libraries' increasing reliance on data-driven methods like classification models and predictive analytics to handle large volumes of information. This trend toward sophisticated AI applications reflects a shift in library operations, where algorithmic processing aids in handling extensive datasets, supporting research, and facilitating advanced information retrieval. Libraries' use of data-driven models underscores the importance of efficiency and accuracy in their expanding digital environments.

AI in Language Processing and Information Analysis

Encompassing 275 articles with keywords like model, management, knowledge, library, and data, this theme explores AI's growing role in language processing and information analysis, particularly in supporting multilingual access and bibliometric evaluations. Given the globalized nature of research and information needs, libraries increasingly turn to AI-powered language processing tools to meet diverse linguistic requirements. This expansion of AI in language processing and information retrieval aligns with libraries' goals to support international research and cater to a broader audience.

Discussion

The findings reveal a dynamic progression in the role of libraries as they increasingly incorporate AI technologies, positioning themselves not only as information providers but as active participants in digital transformation. Across themes, a clear trend emerges in which

libraries are evolving their traditional functions to meet contemporary needs in academic, business, and technological contexts.

One prominent area of transformation is the integration of AI literacy programs within academic libraries (Mutia et al., 2024). Libraries are becoming vital in fostering digital competencies among students and staff, transitioning from passive information repositories to proactive environments where librarians engage as educators and co-creators of AI-driven resources. This shift reflects a broader educational trend where AI literacy is essential for personalizing learning and enhancing academic support. The shift underscores the library's evolving role in preparing students for AI-driven environments, with AI literacy emerging as a critical competency.

In parallel, the incorporation of AI into educational and business models within library contexts represents an expanding scope beyond information storage to supporting diverse, digitally inclusive educational experiences. Libraries are now integral to fostering digital literacy and adaptability, particularly by promoting critical AI skills among learners and staff (Masrek et al., 2024). This trend reveals an expanded function of libraries as bridges between academic and professional sectors, as they develop resources that serve both students and industry professionals, underscoring libraries' potential to foster pragmatic, digitally adaptive skills.

Libraries are also increasingly providing smart services that prioritize user-centered experiences. The adoption of natural language processing, sentiment analysis, and interactive tools such as ChatGPT highlights libraries' commitment to personalization and responsiveness (Panda & Kaur, 2024). This transformation positions libraries as smart service providers, though disparities in regional adoption indicate that some areas face infrastructural and training limitations. Addressing these gaps could standardize access to AI-driven library services globally, aligning with broader goals for equity in digital resources.

Further, libraries are emerging as central players in knowledge and data management (Enakrire & Smuts, 2023), reflecting a trend where they extend their roles beyond traditional information services to support complex data-driven knowledge ecosystems. Libraries are leveraging AI to handle data organization, particularly in fields intersecting with societal challenges like healthcare information systems and Big Data management (Li et al., 2019). This evolution highlights libraries as integral components of modern knowledge infrastructures, contributing to cross-disciplinary research by managing and disseminating large volumes of information.

Specialized applications of machine learning, such as data verification and categorization, illustrate a growing emphasis on ensuring information accuracy (Sivaraj et al., 2024). Libraries are adopting machine learning models that allow for advanced indexing, pattern recognition, and validation, crucial for upholding credibility in the age of digital information (Bhattacharya, 2024). This trend shows a commitment to leveraging AI for accuracy, underscoring libraries' role as trusted information sources amid increasing concerns about information integrity.

Data-driven models, such as classification and predictive analytics, are also on the rise within libraries, reflecting a shift toward sophisticated AI applications (Litsey & Mauldin, 2018). Libraries are prioritizing efficiency and precision, using AI to manage large datasets and support complex research needs. This data-centric approach enhances libraries' capacities as essential research partners, emphasizing a focus on algorithmic methods that streamline data handling and retrieval for advanced research tasks.

Finally, AI's role in language processing aligns with the globalized nature of contemporary research, enhancing libraries' capacity to provide multilingual resources and support international research collaboration (Panda & Kaur, 2024). Language processing and bibliometric analysis tools enable libraries to meet diverse linguistic requirements and offer evaluative services that support researchers in tracking publication trends and impact. This focus on inclusivity and accessibility in language resources positions libraries as global knowledge facilitators, supporting equitable access to information across languages and cultures.

Taken together, these trends illustrate a redefined role for libraries as adaptable, technologically advanced institutions. Libraries are evolving from static collections to dynamic centers of learning and innovation, bridging traditional educational functions with advanced technological capabilities. Addressing disparities in AI adoption will be crucial to standardizing these benefits, and with continued investments in infrastructure and AI literacy, libraries are well-positioned to support diverse, global audiences in the era of digital information.

Conclusion

This study has explored the application of AI in library and information science, revealing seven key themes that characterize the current landscape of AI research within libraries. Through a topic modeling analysis using LDA we identified major themes such as AI's role in supporting student engagement, enhancing business and educational frameworks, developing smart library services, advancing knowledge and data management, facilitating machine learning applications, implementing data-driven classification models, and enhancing language processing capabilities. These findings demonstrate the breadth of AI's potential impact on libraries and emphasize both well-established and emerging areas of focus.

The implications of these findings are significant for researchers, practitioners, and policymakers seeking to leverage AI to enhance library services. By identifying these themes, this study provides a roadmap for understanding where AI is currently applied in libraries and where future efforts may be needed. Libraries are increasingly adopting AI to personalize services, manage vast data resources, support digital literacy, and broaden access to multilingual and multi-disciplinary knowledge. These advancements have the potential to redefine libraries as dynamic, technology-driven knowledge hubs, capable of meeting the diverse needs of users in a digital-first world. For practitioners, this analysis underscores the importance of investing in AI literacy, infrastructure, and cross-disciplinary collaborations to maximize AI's benefits. For policymakers, supporting the integration of AI in libraries will require both structural and financial backing to ensure equitable access to these advanced technologies.

One limitation of this study is its reliance on articles indexed exclusively in the Scopus database, which may not capture the full spectrum of AI-related research within library science, particularly from other sources or regional publications. This reliance on Scopus could limit the generalizability of the findings, as additional themes or insights might emerge from other databases.

Future research could expand upon this work by incorporating other databases, such as Web of Science or specialized library science collections, to ensure a more comprehensive understanding of AI applications in libraries. Additionally, exploring interdisciplinary collaborations and investigating the impact of AI implementation in real-world library settings

could further enhance our understanding of how AI can shape library services. Longitudinal studies on AI adoption and effectiveness within libraries would also provide valuable insights into the evolving role of AI in library and information science.

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