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"Hey librarian, what can AI and analytics do for you": a systematic literature review and sociotechnical perspective

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Abstract

Purpose – This study aims to provide an in-depth overview of current research on artificial intelligence (AI) and analytics applications in library operations, emphasizing their adoption's technical and social implications.
Design/methodology/approach – The study follows the PRISMA guidelines to synthesize existing research on AI and analytics in academic libraries. This review uses sociotechnical systems (STS) theory as a framework to evaluate the technical aspects and social dynamics involved in integrating these technologies.
Findings – The findings indicate that AI and analytics can significantly enhance library resource management, decision-making and user services. However, ethical, social and technical challenges, including staff training and collaboration, must be addressed to ensure responsible implementation.
Originality/value – This study provides the first STS-informed analysis focusing on applying AI and analytics within academic library operations. It offers actionable insights into these technologies' unique applications and potential, bridging a gap in the literature on library-specific operational management.

Keywords Library, Artificial intelligence, Analytics, Sociotechnical system, Adoption, Review
Paper type Literature review

1. Introduction

Academic libraries are strategic entities designed to support institutional goals through their value for students, faculty, and the institution (Oakleaf, 2010). However, the rapid evolution of digital technologies makes academic libraries face multiple challenges in efficiently managing resources, providing seamless services, and meeting diverse stakeholder needs (Cox, 2021; Maleksadati *et al.*, 2023). For example, increased online data availability has made research more data-intensive, forcing librarians to acquire new skills, resources, and infrastructure to provide adequate research support services (Koltay, 2019; Zhang *et al.*, 2023a). The COVID-19 pandemic made things more challenging for library professionals as online teaching and learning became the new normal, creating a radical shift towards new library service demands (Huang *et al.*, 2021; Martzoukou, 2021).

In response to these challenges, library professionals increasingly assess the potential value of artificial intelligence (AI) and analytics technologies in library operations. AI refers to "a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation" – p. 15 (Kaplan and Haenlein, 2019). Meanwhile, analytics technology refers to technologies that support a "systematic thinking process that applies qualitative, quantitative, and statistical computational tools and methods to analyze data, gain insights, inform, and support decision-making" – p. 51 (Power *et al.*, 2018). Together, these technologies emerge as strategic for academic libraries seeking to enhance operational efficiency, optimize resource management, and improve user experiences in today's digital age (Hussain, 2020).

Integrating AI and analytics promises to revolutionize traditional library functions, from collection management to user support, through data-driven insights and automated processes (Noh, 2015; Oakleaf *et al.*, 2017). However, a systematic review of the existing literature is

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imperative to comprehensively understand the scope and implications of AI and analytics within academic library operations management. Previous reviews on adopting AI and analytics in academic library contexts have focused on broad opportunities and challenges (Echedom and Okuonghae, 2021; Shahzad *et al.*, 2024). However, understanding the value that specific AI and analytics technologies, techniques, or practices can bring to library operations management and how their implementation would influence institutional structures, workflows, and user experiences is paramount to implementation success.

This systematic literature review (SLR) aims to provide academic librarians and leaders in the higher education community with (1) a comprehensive overview of the current state research on the applications of AI and analytics in academic library operations management and (2) the technical and social implications of adopting such technologies. Meeting this research objective implies attempting to answer the following overarching research question:

RQ1. How can AI and analytics tools be successfully implemented to support library operations and management?

The importance of this review lies in its potential to inform researchers, library managers or administrators, and institutional policymakers about the specific areas in which AI and analytics can add value to library operations. This SLR will critically analyze the existing literature to elucidate how AI and analytics can optimize library workflows, improve decision-making processes, and enhance user services. It also highlights the importance of considering the technical aspects of AI and analytics tools and the social dynamics and organizational culture surrounding their adoption and use. We use the sociotechnical systems (STS) theory to emphasize the need for collaborative approaches involving technical expertise and social considerations to ensure the successful integration of AI and analytics in library operations management.

This study is original and differentiates itself from extant research (Barsha and Munshi, 2024) in that while previous research has explored the general opportunities and challenges of AI and analytics in academic libraries, our study uniquely focuses on the specific applications of these technologies within the context of library operations management, informed by STS theory. The theory provides a novel framework for understanding the integration of these technologies within the social and technical structures of academic libraries. Hopefully, this study will stimulate further discussion on the ethical, social, and technological implications of AI and analytics in library operations management.

2. Related studies

Integrating AI and analytics into academic library operations has garnered significant scholarly attention recently as libraries aim to optimize services, resources, and user experiences. Several studies have delved into using AI and analytics in academic library operations to support individuals with diverse learning needs, emphasizing the need for intelligent systems to enhance academic library support in student success (Kharbat *et al.*, 2020). Some focus on learning analytics adoption in academic libraries, highlighting its potential to improve student outcomes while addressing ethical and privacy concerns (Jones and Salo, 2018; Jones *et al.*, 2020).

Indeed, using AI and analytics in academic libraries poses moral and ethical dilemmas, particularly concerning user privacy and well-being (Jones and Salo, 2018; Jones *et al.*, 2020). Prioritizing ethical considerations and embedding them in technological designs is crucial to obtaining positive impacts of AI and analytics in academic libraries investing in these technologies to achieve digital transformation and enhance library services (Doty, 2020; Komosany and Alnwaimi, 2021; Oakleaf *et al.*, 2017). Meanwhile, other studies have focused on leveraging AI and analytics to personalize library services, underscoring the importance of understanding users' unique needs to enhance service quality (Khavidaki *et al.*, 2023). Therefore, training programs to update library professionals' knowledge of technology

integration, especially regarding data librarianship, is critical for successfully implementing AI and analytics in academic libraries (Koltay, 2019; Mansour, 2017; Semeler *et al.*, 2024).

The themes emerging from this literature illustrate the evolving landscape of AI and analytics integration in academic library operations, emphasizing ethical considerations and personalized services to enhance library services and support student success. These studies contribute valuable insights into the application of AI and analytics in academic library contexts, laying a foundation for future research to leverage these technologies to enhance learning outcomes and advance knowledge in library and information science (Borgohain *et al.*, 2024; Cox, 2023; Cox and Mazumdar, 2022; You *et al.*, 2024).

Nevertheless, no study provides a unified overview of research-based evidence of how different AI and analytics tools or techniques can support library professionals in different aspects of their jobs. The sparsity of knowledge makes it difficult for professionals to know where the different technologies can be relevant, making adopting AI and analytics for library operations very challenging. This study attempts to address the gap by providing researchers and professionals with a clear understanding of research-based evidence of how AI and analytics can support library operations management, particularly focusing on concrete applications, especially from a sociotechnical perspective.

3. Theoretical background: sociotechnical systems theory

Sociotechnical systems (STS) theory offers a valuable framework for understanding how AI and analytics tools can enhance library operations and management. This theory emphasizes collaboration between human participants and technology to navigate organizational uncertainties and variations (Trist, 1981; Trist and Bamforth, 1951). It advocates improved operational performance by involving workers in system design and granting them control over processes (Pasmore *et al.*, 2019). Thus, effective STS design requires understanding human and machine behavior (Muller, 1989). Design principles that facilitate coordination within STS environments include compatibility, task specification, control of variances, multifunctionality, flexible boundaries, efficient information flow, supportive social systems, human-centered design, and iterative improvement, emphasizing continuous improvement through redesign analysis (Cherns, 1976).

In today's rapidly evolving technological landscape, STS thinking remains relevant as Industry 4.0 technologies outpace organizational designs (Pasmore *et al.*, 2019). This paradigm offers a flexible change model to align the social dynamics of organizations with the technology they seek to adopt (Appelbaum, 1997). Thus, STS theory can serve as a meta-theoretical approach to understanding the integration of AI and analytics tools within modern organizations to support workers in their operations (Bostrom *et al.*, 2009; Sony and Naik, 2020). Previous research provides evidence of the relevance of using STS as a theoretical lens to understand organizational-level technology adoption and use in libraries, highlighting libraries as STS (Manoff, 2015; Rosenbaum and Joung, 2004; Tammaro, 2024). The theory would serve as a basis to highlight the importance of considering the technical aspects of AI and analytics tools, social dynamics, and the organizational culture surrounding their adoption and use in academic library operations.

4. Methodology

This SLR follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency, rigor, and reproducibility in the review process (Page *et al.*, 2021; Petersen *et al.*, 2021). PRISMA was specifically chosen due to its well-established framework for ensuring comprehensive and unbiased literature synthesis, which is crucial for accurately capturing the diverse and interdisciplinary nature of research on AI and analytics in academic libraries. Additionally, this SLR was guided by STS principles, which emphasize the need to consider both technical factors (e.g. AI and analytics tools, data

management practices) and social dynamics (e.g. library staff, organizational culture) when analyzing the integration of AI and analytics. This theoretical alignment ensures that our review identifies relevant technological applications and critically examines their implications within the broader social context of academic libraries.

The Web of Science (WoS) and Scopus databases were searched using variations of terms characterizing artificial intelligence and analytics ("Artificial intelligence" OR "Artificial neural network" OR "case-based reasoning" OR "cognitive computing" OR "cognitive science" OR "computer vision" OR "data mining" OR "data science" OR "deep learning" OR "expert system" OR "fuzzy linguistic modelling" OR "fuzzy logic" OR "genetic algorithm" OR "image recognition" OR "k-means" OR "knowledge-based system" OR "logic programming" OR "machine learning" OR "machine vision" OR "natural language processing" OR "neural network" OR "pattern recognition" OR "recommendation system" OR "recommender system" OR "semantic network" OR "speech recognition" OR "support vector machine" OR "SVM" OR "text mining" OR "analytics" OR "voice assistant" OR "digital assistant") and academic libraries ("academic library" OR "school library" OR "university library" OR "college library").

The use of 'OR' in the search strategy was deliberate to ensure a comprehensive capture of literature. This approach allowed the inclusion of all relevant studies that addressed any aspect of AI and analytics in academic library operations, thus broadening the scope of the review while ensuring that no pertinent literature was missed. The main variations were to include plurals of these terms and include keywords suggested by the databases for comprehensiveness. The search returned 374 documents on WoS and 654 on Scopus, thus a total of 1,028. Six hundred forty-five documents were removed for duplicates after merging the results, and 56 were removed for not being in English, leaving us with 327 screened documents. Ninety-three documents were further excluded for being books, retracted papers, editorials, or reviews, leaving 234 documents for retrieval. We could not retrieve 18 documents due to their absence in journal databases, leaving us with 216 documents assessed for eligibility. Documents were excluded from our analysis if they did not directly relate to the applications of AI and analytics in library operations. Thus, 54 documents were excluded based on an assessment of their keywords, titles, and abstracts, and 91 based on content analysis. Hence, 71 documents were thoroughly analyzed.

The documents included in this review are peer-reviewed articles and conference papers published in English from 2003 to March 31, 2024. Data was extracted in a standardized format to include the reference, AI and analytics tool, application in library operations, added value, technical considerations, and sociocultural considerations, which align with this study's objectives.

The screening and data extraction were conducted by two independent reviewers, who resolved discrepancies through discussion and consultation with a third reviewer for consensus. This approach also helped minimize data extraction risks and reporting bias.

5. Results and discussion

This section reports and discusses the results of the SLR. The findings link to the research question by highlighting specific AI and analytics applications in resource management, decision-making, and user services that enhance library workflows. The results emphasize that successful implementation depends on considering technical aspects, such as data management and integration, and social dynamics, like ethical considerations, staff training, and user engagement. These insights align with the STS framework, which underscores the importance of harmonizing technology with social and organizational contexts to ensure AI tools are technically effective and socially and ethically appropriate within the library setting. Detailed analyses are presented below in four main sections: (1) the value of different AI and analytics technologies or approaches, (2) technical implications, (3) social implications, and (4) sociotechnical implications.

5.1 Value of different AI and analytics technologies or approaches

5.1.1 Data mining. Data mining integrates traditional statistical analysis with techniques from fields like machine learning to model and detect patterns (Jackson, 2002). It uses either hypothesis-driven or data-driven approaches to reveal trends in large datasets. It applies not only to numerical data but also to text (text mining) (Lowe *et al.*, 2021) and bibliographic data (bibliomining) (Azam *et al.*, 2013; Firat and Aslay, 2022). In library operations, data mining extracts insights from bibliographic and textual data, identifying borrower behavior patterns to optimize management and budgeting (Azam *et al.*, 2013). By analyzing usage trends, libraries can allocate resources more effectively and adjust acquisitions based on demographic and preference data, aiding in strategic investment (Firat and Aslay, 2022). Data mining also automates collection development, identifying factors affecting borrowing rates and supporting informed collection-building (Nicholson, 2003; Ochilbek, 2019). Furthermore, usage data helps libraries tailor procurement, aligning with user interests to enhance satisfaction (Xia and Liu, 2019). Libraries can also develop targeted interventions to support academic success through user pattern analysis, improving learning outcomes (Renaud *et al.*, 2015). Lastly, analyzing citation and keyword patterns enhances research discoverability and supports scholarly activities (Lowe *et al.*, 2021). Figure 1 summarizes our findings.

5.1.2 Recommendation system. Recommendation systems personalize service offerings based on user preferences, either explicitly collected or inferred, guiding users toward tailored products or services (Park *et al.*, 2012). AI-driven recommendation systems that support library operations often enhance book discovery by analyzing user preferences. This practice improves search efficiency and reduces manual search costs, making library operations more cost-effective (Ahmed and Letta, 2023). By recommending materials aligned with individual interests, these systems improve learning and user experience, ensuring users find content suited to their objectives (Liu and Hatamleh, 2022; Verma and Patnaik, 2024). Additionally, they can recommend ebooks tailored to user tastes, increasing engagement (Giannopoulou and Mitrou, 2020; Verma and Patnaik, 2024). Beyond books, recommendation systems facilitate research access by analyzing citation patterns and research trends. They provide personalized document recommendations that aid researchers in staying current in their fields (Dhanda and Verma, 2018; Yang *et al.*, 2022). For students, these systems suggest thesis topics based on individual interests and goals, supporting academic success and career development (Fiarni *et al.*, 2021). Figure 2 summarizes our findings.

5.1.3 Machine learning and deep learning. Machine learning enables computers to learn from data without explicit programming, relying on algorithms to detect patterns (Mahesh, 2020). Deep learning, a subset of machine learning, utilizes multi-layered computational models to analyze complex data patterns across various data types, including images, text, and speech (LeCun *et al.*, 2015). Machine learning and deep learning optimize operations through library pattern recognition and data analysis. For instance, analyzing historical purchasing and

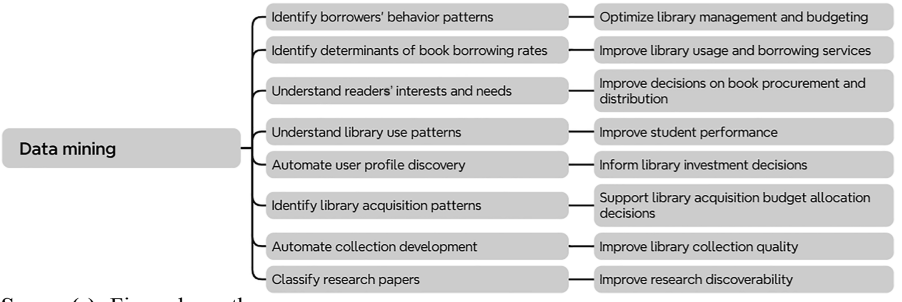

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Figure 1. Value of data mining in library operations

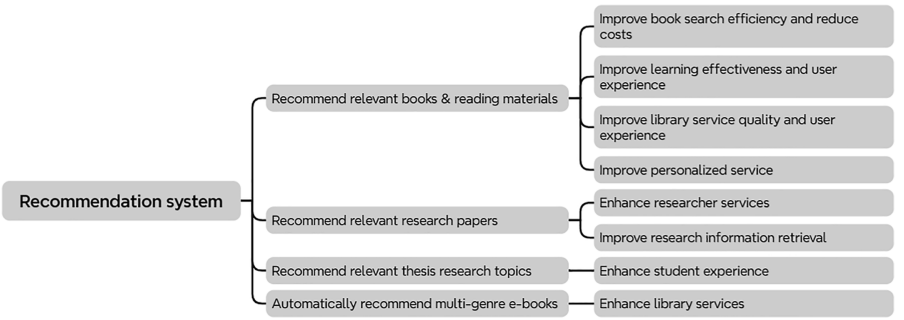

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Figure 2. Value of recommendation systems in library operations

funding data supports efficient budget allocations, ensuring resources align with users' needs (Ruixiang, 2019; Zhou *et al.*, 2024). Libraries can also use these techniques to analyze user preferences for enhanced resource allocation, improving service quality and user satisfaction (Ho *et al.*, 2008; Zhang *et al.*, 2023b). Libraries can personalize user experiences with machine learning in several ways. For example, it can be used to analyze data on academic performance, tailoring interventions to support student success (Hang *et al.*, 2022). It can also be used to enhance user support by analyzing chat transcripts, streamlining response processes (Wang, 2022). Furthermore, machine learning can be used to standardize scholarly metadata. This practice can help enhance research discoverability (Choudhury *et al.*, 2023) and identify institutional research trends (Saputra *et al.*, 2019). Finally, machine learning can guide targeted service quality improvements. For example, it can help with librarian performance tracking (Wang, 2013). It can also assist in energy management by detecting usage patterns that indicate inefficiencies, reducing costs, and supporting sustainability (Li *et al.*, 2019, 2022; Zhou *et al.*, 2020). Additionally, these algorithms can help analyze environmental data to optimize daylight shading for comfort and energy savings (Wen *et al.*, 2023). Figure 3 summarizes our findings.

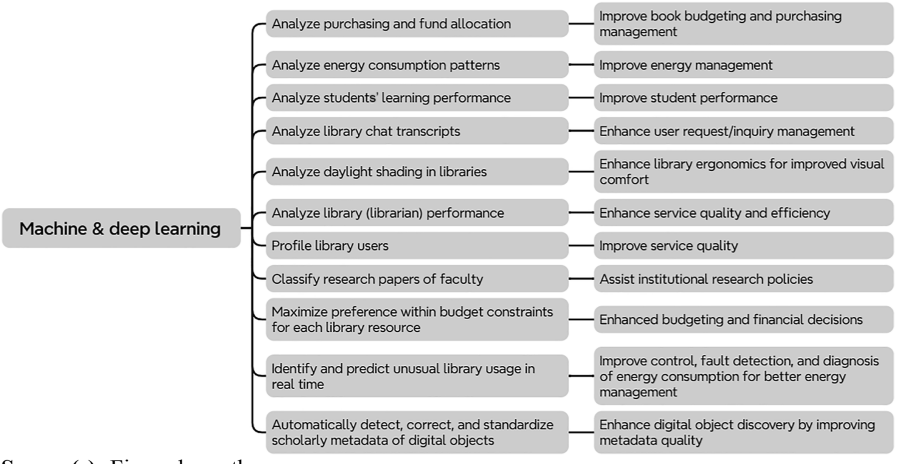

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Figure 3. Value of machine learning and deep learning in library operations

5.1.4 ChatGPT and chatbots. ChatGPT, an AI content generator by OpenAI, enables users to create personalized content automatically (Wu *et al.*, 2023). As an intelligent chatbot, it remembers past interactions, delivers detailed responses, and performs tasks like image captioning and summarization (Liu *et al.*, 2023). ChatGPT can significantly improve library operations by addressing various challenges, particularly student engagement, through innovative pedagogical strategies (Torres, 2024). Libraries can utilize ChatGPT to foster active learning, as it interacts conversationally with students, providing tailored resources, quizzes, and exercises under librarian guidance (Lund and Wang, 2023; Yamson, 2023). This approach could deepen student learning and enrich their educational experience.

Moreover, distinct from rule-based, AI chatbots simulate human conversation with minimal backend intervention and are well-suited for library use (Kaushal and Yadav, 2022; Sanji *et al.*, 2022). With ChatGPT, these chatbots can offer efficient 24/7 reference services, accessible to users regardless of time or location, enhancing user satisfaction (Lappalainen and Narayanan, 2023). They also handle routine inquiries, streamlining access to resources without requiring specialized knowledge, thus freeing library staff to focus on complex tasks (Ehrenpreis and DeLooper, 2022; Rodriguez and Mune, 2022).

5.1.5 Computer vision. Computer vision is a field of AI that enables computers to interpret and understand visual information from the real world (Szeliski, 2022). It involves the development of algorithms and techniques that allow computers to analyze, process, and extract meaningful insights from digital images or videos.

Computer vision technologies can enhance library operations by providing valuable insights into space occupancy, thereby enhancing library space management (Dong and Cheng, 2023). They provide advanced image processing techniques to assess library space occupancy in real-time and identify peak usage times and foot traffic patterns by analyzing live video feeds or static images and monitoring user behavior from strategically placed cameras. This data-driven approach would help track individual movements in the library, informing administrators about space occupancy and popular areas. This information could enable them to optimize library space design, seating arrangements, resource placement, and staff allocation, improving library functionality, usability, and user experience.

5.1.6 Predictive analytics. Predictive analytics leverages data, statistical algorithms, and machine learning to analyze historical and current data, allowing libraries to forecast trends and improve operations (Klimberg, 2023). A primary application is predicting book loan demand, which helps optimize resource allocation and manage loan policies effectively (Sun and Yang, 2017). By analyzing past loan data and user trends, libraries can better meet user demands, minimize stockouts, and enhance loan management. Additionally, predictive analytics aids demand-driven acquisitions by examining user preferences and circulation patterns, guiding libraries in collection development and acquisition strategies to boost relevance and budget efficiency (Jiang *et al.*, 2019). Predicting book purchase needs based on circulation data and market trends further enhances acquisition and stock management (Wu *et al.*, 2022). Such insights support libraries in aligning acquisitions with user demands, improving budget allocation, and maintaining optimal stock levels.

Analyzing usage patterns also enables library administrators to predict resource utilization and allocate resources strategically, enhancing collection development and operational efficiency (Iqbal *et al.*, 2020). This approach helps libraries understand peak usage times, popular areas, and demand fluctuations, which can improve layout, staffing, and resource management (Kanarkard *et al.*, 2017). Finally, predictive analytics can improve energy management by forecasting energy demands based on historical usage and environmental data, helping libraries reduce costs and operate sustainably (Chen *et al.*, 2023). Figure 4 summarizes our findings.

5.1.7 Other types of analytics. Web, sentiment, and visual analytics are valuable tools for enhancing library operations. Web analytics, for instance, enables libraries to assess digital resource usage, providing insights into resource popularity and effectiveness through tools like Google Analytics (Coughlin *et al.*, 2016). This data-driven approach supports the strategic

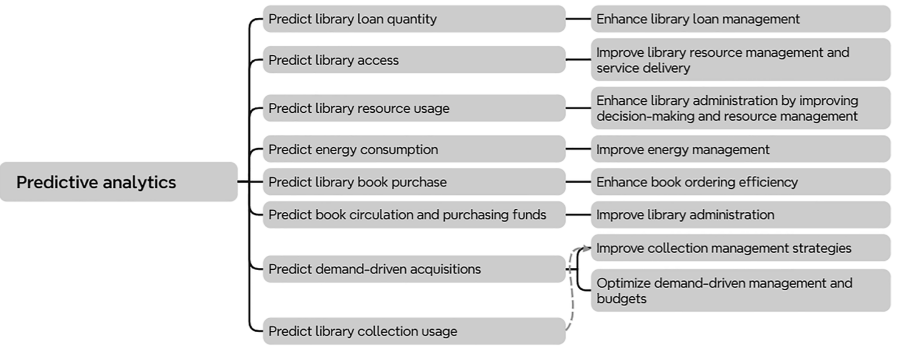

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Figure 4. Value of predictive analytics in library operations

allocation of resources to meet users' evolving needs, informing decisions on acquisitions and enhancing the relevance of library collections. Sentiment analysis of user reviews and comments can reveal user perceptions of library services, helping libraries identify areas for improvement (Hensley and Miller, 2010). By understanding user sentiment, libraries can proactively implement targeted interventions to boost service satisfaction and address user concerns. Visual analytics, which uses charts, graphs, and interactive dashboards, is crucial in presenting library data to stakeholders. By visualizing key metrics and performance indicators, libraries can comprehensively view their impact and value, aiding informed decision-making and resource allocation (Eclevia *et al.*, 2019). This visualization fosters actionable insights into strengths, areas needing improvement, and potential investment opportunities within academic libraries.

5.2 Technical implications

Using AI and analytics in library operations involves a multitude of technical implications, which refer to the foundational and operational data-related aspects critical for the effective implementation of AI and analytics in academic library operations. These aspects include data collection, integration, analysis, and utilization.

5.2.1 Data collection. Collecting diverse data on user behavior, profiles, loan records, bibliographic information, and usage behaviors is crucial for successfully implementing AI and analytics in academic libraries. It entails gathering data on users (e.g. behavior, preferences, comments), library resources (e.g. loan records, book circulation), library usage (e.g. energy consumption, transactions), and system data (e.g. timestamps, chat references). Gathering these diverse and extensive datasets from various sources is crucial for feeding AI and analytics tools. Without robust data collection mechanisms, the potential of AI and analytics to generate meaningful insights would be significantly limited.

5.2.2 Data integration. The successful implementation of AI and analytics in library operations would require integrating data from multiple sources, necessitating robust integration mechanisms. This requirement poses the challenge of unconnected data sources and dealing with very large datasets. Data integration involves integrating data from various sources like HR systems, academic databases, digital library interfaces, and historical records. Efficient integration ensures that disparate data sources are harmonized, allowing for comprehensive library data analysis and utilization. It facilitates a holistic view of library operations and user interactions, enabling informed decision-making and optimization of resources.

5.2.3 Data management. Managing the vast array of data needed to successfully implement AI and analytics in library operations, including historical circulation data, book circulation data, reference transactions, and library visits data, requires efficient storage, organization, and retrieval mechanisms. It would involve utilizing large databases, data warehouses, or other storage solutions capable of handling large volumes of data. Effective data management would ensure that AI and analytics processing data is accessible, secure, and well-organized, enabling library staff and stakeholders to analyze and utilize it seamlessly.

5.2.4 Data analysis. Analyzing data to derive insights for library operations like demand, supply, prices, lending patterns, user behaviors, and preferences is the ultimate goal of using AI and analytics. It would enable libraries to uncover hidden patterns, identify trends, and make data-driven decisions to enhance services and user experiences. It also facilitates optimizing resource allocation, collection development, and service planning based on user needs and usage patterns. However, it implies that academic libraries should have access to the technical data expertise and skills to perform analysis and modeling using AI and analytics techniques. Thus, the role of data librarians becomes critical (Semeler *et al.*, 2019).

5.2.5 Data utilization. Utilizing data for optimizing library operations, improving user experiences, and making informed decisions involves using insights derived from data analysis to enhance services, personalize user experiences, and optimize resource allocation. By leveraging data-driven insights, libraries can tailor services to meet user needs, improve resource access, and enhance overall user satisfaction. Therefore, library administrators should identify areas for improvement, implement targeted interventions, and measure the impact of changes over time.

5.2.6 Data infrastructure requirements. Meeting the infrastructure requirements for handling large datasets, conducting real-time analysis, and ensuring data security and privacy is necessary to successfully implement AI and analytics in library operations. It may involve deploying scalable computing resources, implementing robust data security measures, and complying with data privacy regulations. Adequate infrastructure would enable libraries to process, analyze, and store data efficiently while ensuring library data's integrity, confidentiality, and availability. It would also support the seamless integration of AI and analytics tools, enabling libraries to harness the full potential of data-driven insights to enhance operations and services.

5.2.7 AI and analytics tools. Leveraging AI and analytics tools such as ChatGPT, machine learning algorithms, and data visualization tools can facilitate data analysis and interpretation needed for better library operations management. Indeed, they have the power to enable libraries to process and analyze large volumes of data efficiently, identify trends, uncover hidden patterns, automate tasks, and generate actionable insights to support decision-making. Additionally, they can enable libraries to communicate insights effectively through visualizations, reports, and dashboards, facilitating knowledge sharing and collaboration among library staff and stakeholders. However, these tools should be carefully selected based on the purpose, infrastructure, and skillsets available to the library (Slater, 1984).

5.3 Social implications

Integrating AI and analytics into library operations reshapes the academic experience, transforming how libraries serve students, faculty, and staff. Data mining reveals user behavior patterns, allowing libraries to adaptively meet diverse needs and support inclusive access. Recommendation systems enhance learning by aligning with individual styles and interests, creating a personalized and engaging environment. AI-powered chatbots provide 24/7 support, removing time barriers to assistance. Computer vision and predictive analytics refine space use and resource management, fostering a welcoming and efficient setting. Furthermore, AI-driven energy management promotes sustainability, aligning libraries with corporate social responsibility and paving the way for eco-friendly, user-centered innovation.

Nevertheless, the documents analyzed in this study focused on applying AI and analytics in library operations without precising the resulting social issues. Building on literature criticizing learning analytics, it is not because we can use AI and analytics in library operations that we should (Jones and Salo, 2018; Jones, 2019; Jones *et al.*, 2020). Crucial potential concerns should be addressed to ensure equitable access and ethical use of these technologies within the library context.

5.3.1 Concerns regarding autonomy and consent. The lack of informed consent from students, staff members, and instructors regarding sharing and utilizing their identifiable data for AI and analytics creates concerns regarding the potential deleterious effects on stakeholder autonomy (Doty, 2020; Jones, 2019). Indeed, such practices could contradict the library profession's commitments to user privacy and intellectual freedom. Therefore, stakeholder participation may be crucial for representing and influencing the implementation of the decision-making process. For instance, engaging students in sociotechnical practices that involve collecting, aggregating, analyzing, and acting on data concerning their intellectual behaviors can increase acceptance of AI and analytics.

5.3.2 Scope of surveillance and ethical concerns. The prevalence of analyzable digital trails created by higher education employees emphasizes that the surveillance aspect of AI and analytics extends beyond students. The collaboration between colleges and universities with vendors for surveillance of copyrighted information, along with data leaks and the aggregation of sensitive data, raises significant concerns. This data, including passwords and real-world identities, could be accessed by malicious actors, leading to further risks. Additionally, various entities might subject student and faculty data to legal or illegal investigations, posing potential privacy breaches (Doty, 2020). Furthermore, the involuntary self-awareness experienced by students, internal and external stigmatization, power imbalances, algorithmic biases, self-fulfilling prophecies, establishing new privacy norms, and maintaining trusting relationships are significant ethical concerns faced by those subjected to AI and analytics (Doty, 2020; Jones and Hinchliffe, 2023).

5.3.3 Potential solutions. Professional codes of ethics like the American Library Association (ALA) Code of Ethics and the Federal Educational Rights and Privacy Act (FERPA) in the US can offer essential guidance on how to navigate ethical grey areas (Doty, 2020; Jones, 2019). Of course, other countries should consider contextual codes of ethics. However, interpretations and applications of these principles vary depending on institutional contexts and practical considerations like librarian awareness and institutional priorities. The most crucial ethical oversight should come from Institutional Review Boards, which should enforce well-considered data governance principles addressing ethical concerns associated with using AI and analytics in library operations (Jones, 2019). Academic libraries should also develop public-facing privacy policies and ensure patron awareness of how their data is used for AI and analytics and how it is protected (Mann *et al.*, 2023). Advanced tools can be used to support privacy initiatives, especially during web analytics, since user data on the Web and the Internet is highly exposed to privacy issues (Quintel and Wilson, 2020).

5.3.4 Skill and knowledge gap mitigation. Most Library and Information Science (LIS) professionals lack the skills and preparation to lead quantitatively rigorous AI and analytics projects. Collaboration with individuals, in-house or external technical expertise with advanced methodological education is essential (Jones, 2019). Library staff should also cultivate ethical awareness through targeted continuing education efforts and seek support from professional organizations to bridge knowledge gaps concerning data ethics (Jones, 2019).

5.4 Sociotechnical implications

This research underscores the nuanced relationship between technical and social systems in the effective integration of AI and analytics in academic libraries, framed through the lens of STS theory. Each AI and analytics technology or technique, from data mining and

recommendation systems to chatbots and predictive analytics, actively interacts with and transforms the social dynamics within libraries. These technologies streamline resource management and operational efficiency, shaping user experiences by providing personalized recommendations and enabling data-driven service customization.

However, adopting AI and analytics extends beyond mere technical upgrades; it necessitates fundamental shifts in organizational structure and practices, including resource allocation, budget planning, and administrative processes. For example, chatbots enhance user support services, potentially reshaping staff roles. Ethical and social implications like data privacy, algorithmic fairness, and job displacement further complicate this integration. Addressing these concerns requires libraries to uphold AI technologies' transparency, accountability, and fairness standards.

Adapting to this sociotechnical convergence involves training staff, fostering an innovative culture, and engaging stakeholders to ensure the effective use of these tools for balanced library development. By embracing this synergy, libraries can enhance operational effectiveness, enrich user engagement, and fulfill their mission of democratizing access to information in the digital era. Table 1 summarizes the connection between the research question (*how can AI and analytics tools be successfully implemented to support library operations and management*?) results and the STS-driven discussion of this study.

5.5 Practical implications

The research has several practical implications that can guide library administrators and stakeholders in leveraging these technologies effectively. First, AI and analytics can optimize resource management by identifying usage patterns, enabling libraries to allocate budgets more efficiently, and streamlining collection development based on user needs. Recommendation systems can enhance the user experience by personalizing resource

Table 1. Summary of findings and main conclusions

Aspect of research question	Key findings	Sociotechnical considerations
Optimizing resource management	AI tools like data mining and machine learning can analyze user behavior, borrowing patterns, and resource usage to optimize budget allocation and acquisitions	Implement predictive analytics and machine learning models to forecast resource needs, streamline acquisitions, and manage budgets effectively
Enhancing decision-making processes	AI-driven analytics enable data-driven decision-making by identifying trends, patterns, and user preferences through advanced data analysis	Integrate AI tools like recommendation systems and deep learning to support decision-making in areas such as collection development and user services
Improving user services	Recommendation systems and AI-powered chatbots personalize user interactions, improving access to relevant materials and enhancing user satisfaction	Deploy AI-based chatbots and recommendation systems to provide personalized services, such as tailored reading recommendations and 24/7 support
Addressing ethical and social implications	Ethical concerns include data privacy, algorithmic bias, and the need for user consent. Social implications involve the impact on staff roles and user trust	Develop and enforce strict data governance policies, provide AI usage transparency, and offer staff training on ethical AI practices
Fostering collaboration and staff training	Successful AI integration requires collaboration between technical experts and library staff and continuous training on new technologies	Establish continuous professional development programs for library staff and encourage collaboration with IT departments and AI specialists

Source(s): Table by authors

suggestions. Meanwhile, predictive analytics can aid in anticipating demand for resources, allowing for proactive management of inventory and services. Furthermore, AI-driven chatbots can provide 24/7 support, improving user satisfaction and accessibility. However, this implementation requires addressing ethical concerns around data privacy, ensuring that user data is securely handled, and staff training to manage AI tools effectively. By focusing on both technological capabilities and the social dynamics of library environments, libraries can use AI and analytics to enhance operational efficiency and foster a user-centered, ethical, and adaptable library service ecosystem.

5.6 Limitations and future research

One limitation of this study is that it relies only on articles and conference papers indexed in the WoS and Scopus databases, which may introduce publication bias. This bias can affect the comprehensiveness and representativeness of the review's findings, potentially skewing the overall potential of AI and analytics technologies in libraries. Despite efforts to include all relevant studies, the scope and coverage of the SLR were limited by language restrictions (English), database selection, and search terms. Consequently, essential studies or findings may be overlooked if published in another language or another database or not included in our search terms and related variations, leading to gaps or biases in the review's conclusions. Additionally, variations in study design, methodology, and reporting standards across different studies can make it challenging to evaluate the reliability and robustness of the evidence accurately. Emerging research or innovative applications of AI and analytics technologies may not be adequately represented due to the time lag between research conduct and publication.

Furthermore, the findings of the SLR may lack generalizability to diverse library settings and contexts due to variations in organizational structures, resources, user demographics, and technological infrastructure. What works well in one library environment may not necessarily apply to others, making it challenging to extrapolate findings and recommendations across different settings. Additionally, contextual factors such as cultural norms, legal frameworks, and institutional policies may influence the implementation and outcomes of AI and analytics technologies in libraries. Despite these limitations, this study successfully informs decision-making in implementing and evaluating AI and analytics technologies in library operations. Future research could explore other academic database collections and information sources to complement this review and investigate more contextual determinants of successful implementation.

6. Conclusions

Our synthesis of AI and analytics applications provides actionable insights for academic library leaders, being the first to offer a detailed, STS-informed analysis of how these technologies can be integrated into library workflows, thus setting this study apart from prior research and filling a critical gap in the literature. The results demonstrate that the successful integration of AI and analytics in academic libraries hinges on a balanced approach that addresses technical and social factors. Technically, the effective use of AI and analytics requires robust data collection, integration, management, and analysis systems alongside advanced AI and analytics tools tailored to library-specific needs. Equally important are the social considerations, such as staff training, ethical data management, and fostering a collaborative culture that supports adopting these technologies. By aligning these technical requirements with the social dynamics of library environments, AI and analytics can significantly enhance decision-making processes, optimize resource management, and improve user services, thereby fulfilling their potential to transform library operations effectively. A critical next step would be to contextually assess academic library readiness for AI and analytics from a sociotechnical standpoint.

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