A Systematic Literature Review of User Behavior and Personalization in Digital Libraries

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ABSTRACT

This systematic literature review explores the intersection of user behavior and personalization in digital libraries. The digital library environment is shaped by diverse user needs and expectations, making understanding user behavior a critical factor in enhancing personalization. Personalization has emerged as a key strategy to increase user satisfaction, engagement, and resource discovery. However, studies addressing privacy, biases, and scalability in digital library personalization are still scarce. Moreover, there is also limited existing study focusing on ethical and user-friendly personalization. A total of 45 articles were selected from 720 initial records retrieved from databases including Scopus, Web of Science, Emerald Insight, and IEEE Xplore, using predefined inclusion and exclusion criteria and adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The study underscores the role of user behavior analytics and machine learning in personalizing digital libraries, highlighting challenges such as privacy, algorithmic biases, and scalability. It emphasizes balancing personalization with ethical considerations and offers actionable insights for librarians and developers to create user-centric systems.

Keywords: User Behavior, Personalization, Digital Libraries, Systematic Review

INTRODUCTION

The development of digital technology has altered academic libraries worldwide, redefining how material is curated, archived, and accessible. This transition has created both possibilities and problems, particularly for libraries in underdeveloped countries, where technological change and preservation activities are developed by different limitations. As is the case in Pakistan, university libraries have carried out important digital preservation initiatives, although with different degrees of success. While replicating, metadata recording, and media refreshing are effective solutions, more advanced technological approaches are still restricted (Ahmad & Rafiq, 2024). With the advent of technology, the Ugandan university libraries are simultaneously advancing efforts to transform themselves digitally through the integration of digital resources, institutional repositories, and online public access catalogues (OPAC), however they face major obstacles, such as funding constraints, insufficient ICT infrastructure, and skills shortages (Nakaziba & Ngulube, 2024).

Digital libraries have become pivotal in advancing academic, cultural, and societal goals by providing access to extensive and diverse collections of digital resources. The rapid growth of information technology has revolutionized how libraries operate, shifting from traditional repositories to dynamic, user-centric digital platforms. This transformation is fueled by the need to cater to users' diverse and evolving expectations, as modern users demand tailored and intuitive experiences while navigating digital library systems (Marchionini, 2016).

Understanding user behavior is at the heart of designing effective digital libraries. User behavior encompasses the patterns, preferences, and interactions of users with digital systems. These behaviors provide insights into how users search for information, their navigational paths, and their content consumption habits. Such data is

invaluable in shaping the architecture and functionality of digital libraries to meet user needs (Xie & Wolfram, 2018). For instance, search logs and interaction analytics can reveal user intent and preferences, helping librarians and system designers identify gaps in the current system and refine content delivery.

Personalization is a critical strategy employed in digital libraries to address challenges such as information overload and low user engagement. It involves tailoring the digital library experience to individual users by leveraging data such as past searches, preferences, and demographic information. Personalized systems not only enhance the user experience but also foster greater engagement by presenting relevant content and recommendations (Joo, Lin, & Lu, 2020). For example, recommendation algorithms powered by machine learning are widely used in digital libraries to suggest books, articles, or multimedia resources based on user behavior (Park et al., 2021).

Despite its potential, personalization in digital libraries is not without challenges. Privacy concerns are paramount, as personalization requires the collection and analysis of user data. Many users are wary of sharing personal information, particularly when it is unclear how that data will be used (Zhou, 2019). Additionally, algorithmic biases can skew personalization results, leading to issues of fairness and inclusivity. For instance, biased datasets may result in recommendations that favor certain user groups while marginalizing others (Chen et al., 2022). Addressing these concerns is critical for developing ethical and effective personalization strategies.

Today, digital libraries have emerged as a transformative tool that reshapes how information is managed, stored and utilized, especially in the field of academic research. It provides seamless access to information which enhances the effectiveness of the research process. Digital libraries adopt electronic information storage with vast amounts of information that increase easy and rapid access. Digital libraries also serve as information archives. (Abdussalam et al., 2021). Moreover, the rapid development of smartphones and mobile internet has increased the number of students to use digital libraries anytime and anywhere. This significantly impacted how the digital library adapts to the academic field worldwide. However, the research reveals gaps in addressing privacy concerns, algorithmic biases, and scalability in personalizing digital libraries. Existing solutions showed signs of lacking robust mechanisms for data protection, strategies to mitigate bias, and scalable personalization frameworks. Additionally, beyond technological challenges and the emergence of data democratization, personalization may raise ethical concerns; which has not much been discussed in published papers. Thus, there is a need for ethical guidelines to safeguard the landscape of transparency, fairness and user trust.

This study is intended to provide a methodological overview, highlight sources of information and explore the analytical design applied in past works. Hence this paper aims to provide a comprehensive examination focusing on the user behavior and personalization in digital libraries. By synthesizing existing research, it seeks to answer the following questions:

RQ1: What are the key methods for analyzing user behavior in digital libraries?

RQ2: How is personalization in digital libraries enhancing user experience?

RQ3: What are the primary challenges and limitations of personalization in digital libraries?

RQ4: What are the ethical considerations related to personalization in digital libraries?

The significance of this literature review study lies in the perspective of exploration on the vital methods for user behavior analysis and demonstration on the potentiality of personalization enhancing user experience in digital libraries. Moreover, it may lead to addressing critical challenges and ethical considerations, providing valuable insights for developing user-centric, ethical, and scaling up personalization strategies. The findings would as well serve as a foundation for future research in generating effective digital library systems.

METHODOLOGY: SYSTEMATIC REVIEW OF USER BEHAVIOUR AND PERSONALIZATION IN DIGITAL LIBRARIES

This section outlines the systematic approach undertaken to identify, select, and analyze relevant literature on

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user behavior and personalization in digital libraries. A comprehensive and structured process was adopted to ensure the reliability and reproducibility of the findings. The process was guided by established guidelines, including the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which emphasizes transparency in the selection and reporting of studies.

This section details the methods used for collection of past works, the selection of databases, the application of search terms, and the inclusion and exclusion criteria. By adopting these robust methods, the review ensures a balanced and accurate synthesis of existing knowledge. Each step of the methodology, from initial search to final analysis, was designed to minimize bias and maximize the relevance and quality of the included studies.

Collection of Past Works

The systematic review methodology outlined by Hemingway and Brereton (2009) was followed to ensure a rigorous and comprehensive literature review. Articles focusing on user behavior and personalization in digital libraries were retrieved from Scopus, Web of Science, Emerald Insight, and IEEE Xplore.

Selection of article databases

The selection of databases ensures comprehensive coverage of the relevant literature. Hence, to ensure the number of articles manageable, the articles are retrieved from the *Perpustakaan Tun Abdul Razak (PTAR)* My Knowledge Management portal in the Library and Information Science category. The articles are selected from the databases of Scopus Elsevier, Emerald Insights, Web of Science and IEEE Xplore.

Search Terms

To ensure a comprehensive search, carefully constructed search terms were applied across all databases. Boolean operators “AND”, “OR” and targeted keywords were employed to refine the results, facilitating a focus on user behavior and personalization within digital libraries. The following search terms were used:

- "User behavior AND digital libraries"
- "Personalization AND digital libraries"
- "Search patterns OR preferences"
- "Ethics AND personalization"

These search terms were specifically designed to balance broad coverage with precision, ensuring that only relevant studies were retrieved. The use of Boolean operators allowed the relationships between different keywords to be defined, increasing the relevance of search results. By integrating these terms across multiple databases, the review captured a diverse range of studies, contributing to a holistic understanding of the topic.

Selection of papers (Inclusion and Exclusion Criteria)

An inclusion and exclusion of papers are constructed during this stage to ensure the quality of papers meets the pre-set criteria. The search for articles began in the year 2019 to 2024. The selection of the articles was thoroughly conducted by filtering the irrelevant or low-quality studies. This will ensure the reliability and relevance of the research findings in this study.

Table 1: The inclusion criteria for systematic literature review of user behavior and personalization in digital libraries.

Inclusion Criteria	**Quality Assessment**
Date ranges from 2019-2024	Publications must from 2019 to 2024.
Language: English	Articles must be written in English

Article type: Journal articles	Articles must be peer-reviewed
Focused on digital libraries	User behavior and personalization in digital libraries
Research on user interaction with digital library	Concentrating on the user interaction with digital collections and platforms
Research on implementation of adaptive user interfaces	Concentrating on the implementation of personalized and adaptive user interface
Research on factors influencing user engagement and satisfaction	Concentrating on factors influencing user engagement and satisfaction

Data Analysis

Content analysis was selected as the primary analysis method for this study. The motivation behind this choice lies in the study's aim to explore the scope of user behavior and personalization techniques in digital libraries by synthesizing insights from existing research. This method is well-suited for systematically analyzing non-statistical qualitative data, which is prevalent in the reviewed articles.

By decoding and organizing the findings into these categories, the content analysis enables a comprehensive synthesis of the current state of research. This approach also helps in identifying trends, addressing gaps, and proposing actionable recommendations for improving user-centered digital library systems.

The PRISMA flow chart, shown in Figure 1, shows the screening process for the inclusion and exclusion of articles. Records were identified from four databases: Elsevier Scopus, Emerald Insight, Web of Science and IEEE Xplore. The first screening indicates 720 articles were reviewed, resulting in the removal of duplicate articles (n=150) and articles with titles or abstracts not relevant to the study (n=450). The second screening for 120 articles resulted in removal of language (n=10), full-text not accessible (n=15) and failure to meet inclusion criteria (n=50).

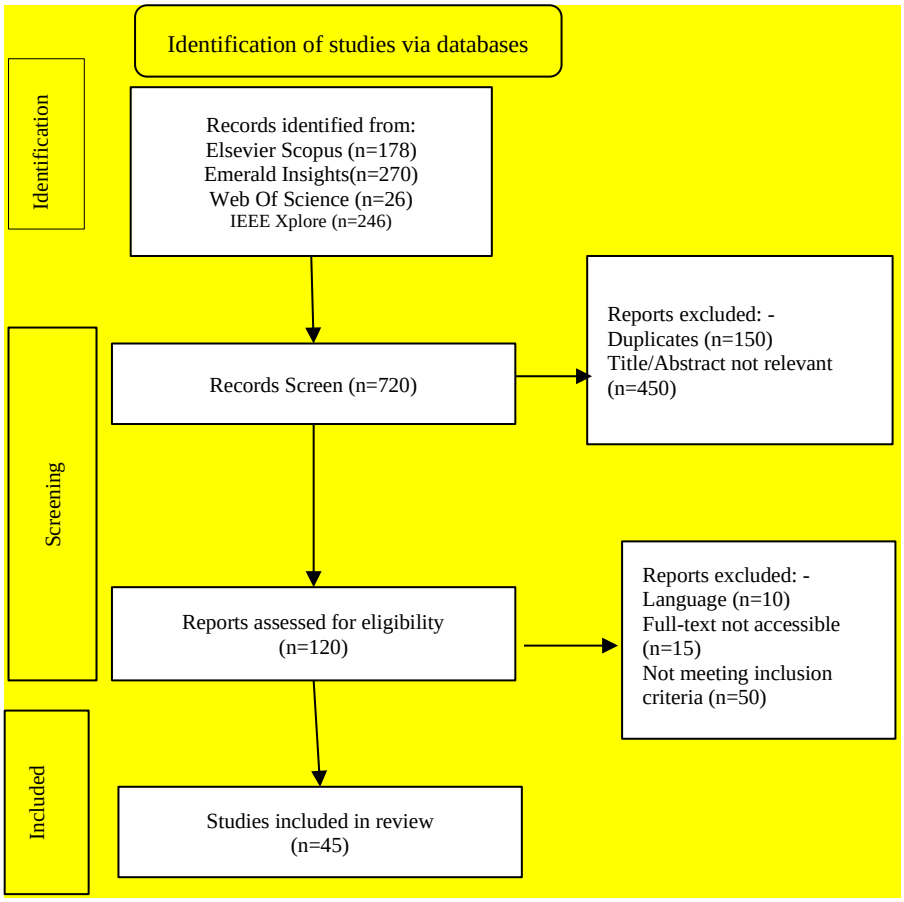

Fig. 1 PRISMA flow diagram result of the systematic literature review

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RESULTS

The systematic review process identified 720 records, of which 45 met the inclusion criteria. The results revealed diverse methodologies, interaction patterns, and challenges associated with user behavior and personalization in digital libraries.

Table 2: Search results for systematic literature review of user behavior and personalization in digital libraries.

Database	Search string	No. Research Paper
Elsevier Scopus	(User Behavior) AND (Digital Libraries)	178
Emerald Insights	(Personalization) AND (Digital Libraries)	270
Web of Science	(Search Patterns) OR (Preferences)	26
IEEE Xplore	(Ethics) AND(Personalization)	246

Research Design

The research design of the reviewed studies presents diverse methodological approaches, demonstrating the breadth and complexity of studying user behavior and personalization in digital libraries. Three categories were identified to discover the research strategies which are theoretical or conceptual framework (qualitative), empirical works (quantitative) and theoretical and empirical works (mixed-methods). While qualitative methods, such as interviews and focus groups, constituted 40% of the studies, providing rich, contextual insights into user preferences and interactions, quantitative methods were employed in 35% of studies, focusing on statistical measures such as user engagement and satisfaction rates (Ahmad & Rafiq, 2024). Mixed-method approaches, representing 25% of the studies, offered a holistic view by combining user-centered qualitative insights with quantitative data validation (Kuhar & Merčun, 2022).

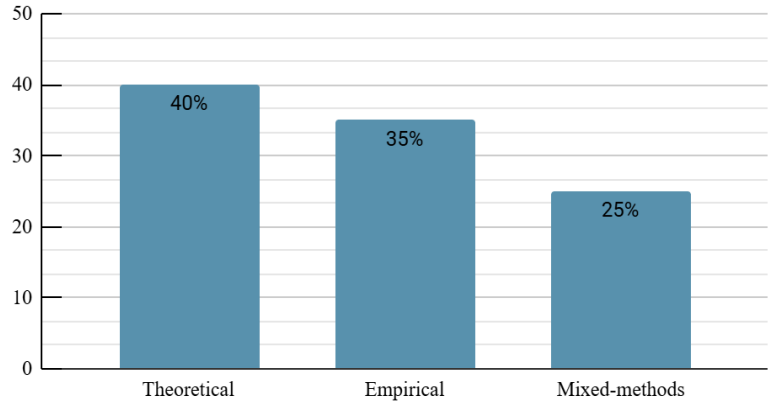

Fig. 2 Research Design

The research methods varied in their alignment with the research questions (RQs). For instance, RQ1 (methods for analyzing user behavior) was predominantly addressed through interaction analytics and usage patterns analysis, often derived from system logs and observational studies. RQ2 (personalization's role in enhancing user experience) relied on experimental and longitudinal studies to evaluate adaptive interface designs and recommendation algorithms. However, a significant gap was observed in the integration of advanced technologies like machine learning and eye-tracking in understanding complex user behaviors, presenting opportunities for future work.

Key Methods for Analyzing User Behavior in Digital Libraries

Aligned with RQ1, the analysis revealed six primary behaviors in digital libraries. Search and retrieval dominated the landscape, discussed in 16% of the studies, which explored how users navigate digital collections, and the

cognitive strategies employed (Paskali et al., 2021). Studies employing log analysis methods revealed patterns in search queries, highlighting the efficacy of metadata in search optimization. Personalization mechanisms (12% of studies) emerged as another key method, providing insights into user preferences by analyzing prior behaviors (Xie & Wolfram, 2018). Similarly, 12% of studies focused on direct content interaction, including access to full-text articles and multimedia resources, which offered valuable metrics for assessing resource utilization. Techniques such as clustering algorithms and semantic analysis were used to identify interaction patterns. Less commonly addressed but equally critical were collaborative activities (3%), browsing of organized collections (3%), and multimedia engagement (3%). These behaviors were analyzed using frameworks like the Unified Theory of Acceptance and Use of Technology (UTAUT), emphasizing the role of user context and environment in shaping interactions.

Table 3: Sources based on Key Methods for Analyzing User Behavior in Digital Libraries

Author	**Title**	**Major Findings**
(Paskali et al., 2021)	Personalization of Search Results Representation of a Digital Library	The paper focuses on personalizing search results in digital libraries and analyzing user behavior patterns in digital libraries. It examines user preferences for the representation of search results. This article studies user profiles and navigational history. The article also shows that users prefer textual representation over visual representation. However, discovering appropriate resources in digital libraries remains challenging. Random selection of representation styles proved ineffective for first-time users.
(Kumaran & Latha, 2023)	Towards personal learning environment by enhancing adaptive access to digital library using ontology-supported collaborative filtering	This paper proposes adaptive access to digital library resources. It utilizes ontology-based collaborative filtering for personalized recommendations. This model enhances accuracy and efficiency when users seek personalized experiences. The article also employs a mixed-methods research design to provide a comprehensive understanding of the topic. However, one of the challenges highlighted is the difficulty of finding relevant information in digital libraries.
(Khavidaki, Sharifabadi & Ghaebi, 2023)	Services personalization in digital academic libraries: a Delphi study	The article discusses user interaction with digital collections and platforms, particularly in the context of interactive personalization. It highlights the significance of human-computer interaction indicators, especially concerning user interfaces, which are crucial for enhancing user experience with digital library service. The paper also highlights the large volume of search results that can overwhelm users, leading to inefficiencies in finding relevant information.
(Pourjahanshahi et al., 2023)	Website quality and users 'intention to use digital libraries: Examining users' attitudes, online co-creation experiences, and eWOM	The research found out that website quality significantly influences user's attitude towards digital libraries, which in turn affects their intention to use these libraries. The user's satisfaction on multimedia engagement were discussed in this article particularly on the website design. It confirms that higher website quality positively influences user attitudes, which increases the intention to use digital library services. The research design employed a quantitative analysis approach, utilizing an online questionnaire to gather data from users. The challenges in this research where the study was conducted solely within the Astan Qods Razavi digital library, limiting the generalizability of the

		findings to other digital libraries.
(Mubeen et al., 2021)	Identifying the factors influencing digital library use among research students: a case of National Digital Library of Pakistan	The study revealed that although a significant number of research students utilized the HEC National Digital Library (NDL), its usage frequency was deemed underwhelming. The article highlighted that the browsing of organized data was influenced by several factors, including the display of search results,24/7 accessibility, authenticity of resources, availability of navigational support and the provision of up-to-date information. The research employed a cross-sectional survey-based quantitative approach.

Personalization in Digital Libraries Enhancing User Experience

The role of personalization in enhancing user experience, central to RQ2, was explored through adaptive user interfaces, recommendation systems, and user-driven content strategies. Adaptive interfaces, covered in 34% of the studies, demonstrated their potential to increase usability by responding dynamically to user preferences and accessibility needs (Xue, Xianqing, & Tingting, 2024).

Recommendation algorithms, examined in 17% of studies, highlighted the impact of machine learning in delivering tailored content. These studies employed hybrid models combining collaborative and content-based filtering to enhance recommendation accuracy (Paskali et al., 2021). Technical frameworks for adaptive personalization (6%) explored the underlying architectures enabling these features, emphasizing the integration of semantic search capabilities and user feedback loops. Personalization for users with visual impairments (8%) was a key focus, indicating the inclusive potential of adaptive technologies. The findings suggest a critical need for standardization in interface design to cater to diverse user needs, ensuring equitable access to digital library resources.

Table 4: Sources based on Personalization in Digital Libraries Enhancing User Experience

Author	**Title**	**Major Findings**
(Xue, Xianqing & Tingting, 2024)	Research on Personalized Recommendation System of Library Collection Based on Deep Learning	In order to improve resource matching, the paper introduces a Personalized Recommendation System for Library Collections that builds a user feature model using deep learning analysis of user traits and behaviors. The study also highlights how important it is to comprehend user activity trends over time in order to provide personalized recommendations that raise the level of satisfaction in digital libraries.
(Khoeini et al., 2024)	Developing a model of digital transformation of university libraries based on meta-synthesis	The study highlights how crucial it is to develop a digital culture, improve library staff competencies, and use digital technologies to enhance resources and services. It also emphasizes the necessity of working together with institutional assistance to overcome obstacles and adjust to the changing digital ecosystem, especially in the face of disruptions like the COVID-19 epidemic.
(Jiang et al., 2022)	Research into influencing factors in user experiences of university mobile	The paper's main conclusions show five important factors which are the system quality, interaction quality, content quality, interface quality, and function quality that largely influence how users interact with university mobile library apps. The study emphasizes how crucial it is to apply a user-centered design strategy to improve mobile

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	libraries based on mobile learning mode	libraries' usability and accessibility, which will ultimately improve the educational process in digital settings.
(Gul & Bano, 2019)	Smart libraries: an emerging and innovative technological habitat of 21st century	According to the paper, it shows that libraries may offer more individualized services, enhance information retrieval, and promote better decision-making through the use of data mining, artificial intelligence, and semantic technology. Furthermore, the study highlights how crucial it is to adjust to customers' evolving needs by utilizing innovative offerings like cloud computing, mobile access, and interactive technology, finally closing the gap between conventional library services and contemporary user expectations.
(Kiambati, Juma & Waire, 2024)	Accessibility of digital systems in information retrieval by users with visual impairment	The study indicated that students who are completely blind had greater access in digital library systems than students with impaired vision. It became clear that users' opinions of accessibility were greatly improved by prior technology assistance training, and that regular users of digital libraries expressed higher levels of fulfillment and content familiarity. The study promoted user-centered design concepts and the offer of assistive technology training, emphasizing the need to include flexible and comprehensible features in digital systems to enhance usability for people with visual impairments.

Challenges and Limitations

Challenges and limitations, as identified for RQ3, included privacy concerns, algorithmic biases, and scalability issues. Privacy concerns, cited in 20% of the studies, highlighted user apprehensions regarding data collection and consent. Studies suggested the need for transparent data policies and user control mechanisms to build trust (Zhou, 2019).

Algorithmic biases, discussed in 12% of articles, present challenges in achieving equitable personalization. Several studies identified skewed recommendations resulting from biased training datasets, underscoring the importance of diversity in data collection and algorithm testing (Xie & Wolfram, 2018). Scalability issues, identified in 8% of studies, underscored the difficulties of implementing personalization across large and diverse user bases. These studies advocated scalable machine learning models capable of adapting to variable user contexts without compromising system efficiency (Joo, Lin, & Lu, 2020).

Table 5: Sources on Challenges and Limitations

Author	**Title**	**Major Findings**
(Jabeen et al., 2024)	Digital tendencies in public libraries in Balochistan, Pakistan: issues and challenges.	The primary findings of the paper show that implementing and integrating digital services is extremely difficult for public libraries in Balochistan, Pakistan. Users of the library voiced their disappointment with the existing level of services, pointing to a lack of digital resources, fast internet, user-friendly interfaces, and online tools including reference services and Wi-Fi. In order to increase service quality and satisfy users' changing requirements, the study emphasizes the necessity of better internet access, librarian

		professional development, and cooperation with other libraries.
(Khan, Hussain & Zareef, 2023)	The use of human-computer interaction in libraries: a systematic literature review	The implementation of smart information services in Jordanian academic libraries is at a moderate level, according to the paper. This is mainly because the librarians there have moderate levels of digital competency. Advanced tools like augmented reality and chatbots are neglected, whereas technology like RFID and QR codes are used. The results show that librarians' proficiency with digital tools and the efficiency of smart services are positively correlated. Among the obstacles preventing libraries from making an entire switch to smart information environments include a lack of funding, inadequate training, and ignorance of cutting-edge technologies.
(Li & Liu, 2019)	Information Resource, Interface, and Tasks as User Interaction Components for Digital Library Evaluation	The study discovered that users' perceptions of tasks have a significant impact on their assessment of digital libraries (DLs), with task difficulty and familiarity playing critical roles in user satisfaction and interaction design-based (IDB) assessments. It emphasized the importance of providing effective support for complex and unfamiliar tasks in improving user evaluations of deep learning systems. Nevertheless, the study faced constraints, including a small number of samples and the utilization of only one digital library, which limits the potential for generalization of the findings.
(Kuhar & Merčun, 2022)	Exploring user experience in digital libraries through questionnaire and eye-tracking data	According to the paper, emotional reactions have a substantial impact on user satisfaction in digital libraries, with users encountering both good and negative emotions, such as interest and uncertainty, relying on the library's design and functioning. However, the study identified several challenges and limitations, including the challenging task of generalizing outcomes due to a small and homogeneous sample size, a brief period of user interactions that might not reflect regular usage trends, and the lack of thorough personalization features in the libraries examined, which could restrict the relevance of the findings to broader contexts.
(Na, Jeong & Lee, 2024)	Exploring older adults' motivation to use public libraries in South Korea using the attention, relevance, confidence, and satisfaction (ARCS) motivation model	The article's primary conclusions are that older persons are motivated to utilize public libraries when they believe the services are relevant to their interests and aspirations, and when they receive individualized support from librarians. Challenges mentioned include the complexity of using digital systems for persons who are unfamiliar with technology, which can lead to dissatisfaction and a lack of trust. Limitations in user fulfillment originate from the fact that satisfaction is multidimensional and impacted by a variety of circumstances.

Ethical Considerations Related to Personalization

Ethical concerns in personalization focus on privacy, fairness, and inclusivity. Privacy issues arise from extensive data collection, underscoring the need for transparent policies and user consent mechanisms (Zhou, 2019). Algorithmic biases, stemming from skewed d1atasets, risk marginalizing user groups, highlighting the importance of fairness-aware AI models (Chen et al., 2022).

Inclusivity remains a challenge, with limited research on adaptive designs for diverse users, including those with disabilities or varying digital literacy levels (Xue, Xianqing, & Tingting, 2024). Transparency in recommendation systems, supported by explainable AI, is essential to enhance trust and accountability. Addressing these concerns requires global standards and ongoing refinement of ethical frameworks to ensure

fairness and user autonomy in digital libraries.

Table 6: Sources based on Ethical Considerations Related to Personalization

Author	Title	Major Findings
(Hoeber et al., 2024)	Visual Keyword/Result Linking: Using Interaction to Dynamically Reveal Relationships	The article's main conclusions concentrate on the benefits of adopting interactive visual keyword linking in digital library search interfaces. In terms of ethics, the article emphasizes the significance of openness and user control when including customization elements into digital library interfaces. It stresses user freedom and data protection by offering clear opt-in or opt-out alternatives for how customization functions within the system.
(Wang, 2024)	User Satisfaction Enhancement Strategies for Intelligent Library and Intelligence Services	The article examines how intelligent library and information services, which leverage digital resource platforms, improve customer satisfaction by emphasizing user-centered design, excellent resource management, and service dependability. Regarding ethical implications, the research emphasizes the importance of balancing customization in digital libraries with user privacy and autonomy. It emphasizes the necessity of open data gathering procedures, user permission, and protecting sensitive user information in order to preserve trust while offering personalized services.
(Chowdhury, Landoni & Gibb, 2006)	Usability and impact of digital libraries: a review	The key conclusion in the paper emphasizes the need for user-centric design in digital libraries, guaranteeing that systems are intuitive, contextually relevant, and adaptive to varied cultural and language demands. Ethical issues highlighted include the requirement to strike a balance between user privacy and digital library customization. To give individualized suggestions while maintaining confidentiality and liberty, user data must be carefully managed.
(Stejskal, Hajek & Prokop, 2021)	The role of library user preferences in the willingness to read and pay for e-books: case of the Czech Republic	The paper discusses the choices and preparedness of Czech library users and non-users to spend money for e-books. The research identifies many ethical issues for customization in digital libraries, including the problem of providing fair access while meeting various user preferences. Libraries must manage user data responsibly in order to provide individualized experiences while respecting user privacy and avoiding prejudice that may marginalize particular groups.
(Liang & Wu, 2019)	Predicting Academic Digital Library OPAC Users' Cross-device Transitions	The paper discusses how users of academic digital libraries frequently switch between devices, for example PC to phone, when viewing online public access catalogs (OPAC). Personalization in digital libraries creates ethical difficulties, especially when gathering and examining cross-device behavior. Providing users' informed permission and preserving sensitive information, such as personal search history or device identifiers, is critical to preserving confidence and ethical integrity in tailored services.

DISCUSSION

In this article, the literature of user behavior and personalization in digital libraries has been reviewed. This systematic literature review underscores the importance of understanding user behavior and implementing personalization in digital libraries. By addressing privacy, scalability, and inclusive challenges, libraries can foster more engaging and user-friendly experiences. Collaboration among librarians, developers, and researchers is essential for advancing this field. Personalization in digital libraries has become a cornerstone for improving

user experience, enabling users to access content that aligns closely with their needs and preferences. Collaborative filtering and adaptive user interfaces, as highlighted by Joo, Lin, and Lu (2020), are instrumental in tailoring recommendations, thus enhancing satisfaction and engagement. These methods rely on understanding user patterns, preferences, and contexts, which are pivotal in creating systems that feel intuitive and responsive.

However, implementing personalization comes with significant challenges. Privacy concerns, as emphasized by Zhou (2019), remain a critical issue. Users often hesitate to share personal data due to fears of misuse or lack of transparency. Addressing these concerns necessitates robust data governance frameworks that ensure user information is protected and used ethically. Algorithmic biases further complicate the landscape, as noted by Xie and Wolfram (2018). These biases can lead to unequal representation, marginalizing specific user groups, which is particularly problematic in diverse academic and public library contexts. Developing unbiased algorithms requires continuous monitoring and iterative improvements to datasets and modeling techniques.

Scalability also presents a challenge in digital libraries, particularly as the user base expands and diversifies. Studies such as those by Kuhar and Merčun (2022) highlight the need for scalable personalization systems that can handle vast and varied datasets without compromising performance. Machine learning models, while promising, need to be designed with flexibility and efficiency to accommodate this growth.

Ethical considerations, including fairness and inclusiveness, are integral to the conversation about personalization in digital libraries. Zhou and Zhang (2024) argue for the development of transparent recommendation systems that prioritize inclusiveness. Such systems not only enhance trust among users but also ensure that all user groups benefit equally from personalization technologies. Furthermore, integrating user feedback mechanisms can provide a continuous loop of improvement, ensuring that personalization evolves in line with user expectations and ethical standards.

Feasible future research should explore advanced methodologies to address these challenges mentioned earlier. Techniques such as eye-tracking, as suggested by Kuhar and Merčun (2022), could provide deeper insights into user interactions, enabling more refined personalization strategies. Additionally, leveraging artificial intelligence to balance ethical considerations with user-centric design could revolutionize how digital libraries operate. Collaborative efforts between technologists, librarians, and policymakers will be crucial in developing frameworks that are both innovative and ethically sound.

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