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Emerging Trends in Information Science: Latest advancement and future directions in libraries

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Abstract

Libraries are transforming in the digital era, evolving from knowledge repositories into hubs of technology, education, and community. Among the latest advancements, VR/AR enables immersive learning, AI enhances personalized services, and blockchain secures digital assets. While these innovations reshape libraries, challenges like budget constraints and the digital divide persist, especially in rural areas. Overcoming these requires strategic partnerships, funding, and inclusivity-focused initiatives. This article highlights libraries' evolution in leveraging technology to ensure equitable access. Future directions include adopting digital ecosystems, utilizing AI-driven analytics, and expanding VR/AR for collaborative learning, cementing libraries as pivotal in a technology-driven world.

Keywords: artificial intelligence, blockchain, digitization, libraries, open access.

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1.0 Introduction

In information science, principles from computer science, library science, studies in communication, and cognitive science have come together as one interdisciplinary area. Mainly, it deals with creating, arranging, retrieving, and distributing information in various forms. The interdisciplinarity of the field itself is one of the influencing factors in the library sciences, with its state-of-the-art frameworks and tools so critical in managing the challenge of complexity wrought by the digital era. Libraries can become more knowledge-centred organisations to better serve the needs of a technologically advanced society by employing the principles of information science (Borgman, 2020).

Libraries are uniquely positioned in the digital age as information, technology, and civic engagement hubs. They should be inclusively welcoming spaces for social and educational activities, offer a variety of technical facilities, including maker spaces and virtual learning environments, and provide access to diverse digital resources. Their growing function highlights their importance in closing the digital gap, promoting digital literacy, and assisting with lifelong learning (Thompson & Riley, 2021).

The necessary level of being current and creative requires continuously understanding new developments within information science. Libraries are increasingly required to innovate into newer technologies, including blockchain, virtual reality, and artificial intelligence, as ways of information access and consumption change. These technologies allow libraries to manage their resources more effectively,

improve user experiences, and adapt to shifts in information usage. For example, blockchain securely accesses digital assets, while AI catalogues and provides personalised recommendations. Other capabilities entailed in virtual reality, as identified by Tait, Martzoukou & Reid (2016), are immersive learning experiences since libraries align themselves with modern educational paradigms.

In today's era of information overload, libraries remain essential institutions in society. Librarians continue their traditional roles of preserving knowledge and fostering literacy. However, their responsibilities have evolved. Librarians now help users find reliable information online, teach digital skills, and ensure everyone has access to resources in both physical and virtual spaces. Even though the means of searching or retrieving information have changed dramatically from book reading to the web and mobile devices, the defining goal of the libraries does not change to deliver information to people in equal quantities irrespective of their level of education. However, the scope of functions of libraries has changed; they are not only passive shelves for books and literature. Now they are active centres of intelligence, technology, and social activity which are addressing a variety of needs of our age. Libraries remain crucial resources for accessing a wide range of items, whether they are digital or traditional. These organisations help to eliminate informational barriers by serving the dual purposes of granting access to books, scholarly journals, and digital resources while advocating for unfettered access to scholarly publications. Libraries also cater to underserved communities in several important ways such as helping to bridge gaps in access to information and technology. They provide free access to books, computers, and the internet, which is especially valuable for individuals in low-income areas who may not have these resources at home. Many libraries also offer digital literacy programs, teach essential skills such as searching for information online, and how to use computers. These programs are crucial for those who lack access to technology. In addition, libraries often reach out to communities through mobile services or partnerships with local organization, making sure that even those who cannot visit a physical library still have access to resources. Libraries also create specific programs or initiatives aimed at promoting digital literacy. For example, the National Library of Malaysia organized "*Program Literasi Media dan Maklumat*" that targeted children under 12 years old, primary school students, and the public community to develop their digital skills, while in rural areas of Africa, the "African Library Project" assist in providing books, technology, and digital literacy training, assisting remote communities in gaining vital skills and access to information.

Additionally, librarians engage with technology and facilitate connectivity both inside and outside of their physical spaces. In addition to providing free computers and internet, they also offer cutting-edge online resources including 3D printers and VR/AR technologies. People have the chance to learn about new technologies and digital literacy because libraries offer these resources.

Libraries encourage collaboration by hosting events, talks, and programs that promote social interaction, self-improvement, and lifelong learning. It involves offering secure settings where people may meet locals and learn new things. Because libraries provide ubiquitous access to the digital world, they play an equally essential role in raising people's knowledge of the digital environment.

Libraries face significant challenges as a result of the shift to a high-tech, sophisticated society, the shift from print to electronic information, and the declining use of printed information resources in libraries and information centres. These days, a library's definition is determined by the variety of activities it offers rather than by its resources, hardware, or output. Libraries must make sure that the right infrastructure and human resources are available to meet the needs of their demanding digital-age patrons. Technology has influenced librarianship in several ways, including how librarians see themselves, their position, and the organisation they work for. In the digital world of today, a librarian's job.

The new developments in the field of information science are transforming the role of libraries in society as well as their functionalities in serving users. These developments, which include digital and virtual libraries, cloud computing, AI-aided processes or services, and VR, empower libraries to become more user-friendly, effective, and accessible. Libraries are actively addressing these emerging trends by incorporating them into their services. By embracing technologies like AI for personalized services, cloud computing for remote access, and virtual reality for immersive learning experiences, libraries are enhancing their ability to reach and serve a broader user. In this age, when trends are rapidly evolving, libraries are not just keeping pace, they are actively transforming into dynamic information hubs that continue to gain importance and relevance in the digital era.

This study aims to examine the transformation of libraries in the digital era, focusing on how emerging technologies such as AI, VR/AR, and blockchain are being integrated to enhance educational services, secure digital resources, and promote equitable access to underserved communities while also addressing the ongoing challenges related to infrastructure, funding, and inclusivity.

2.0 Literature Review

2.1 Emerging Technologies in Libraries

Technological advances in library operations are promoting better user experiences, efficiencies, and creative learning opportunities. Among the most revolutionary technologies reshaping library functions are blockchain, virtual/augmented reality (VR/AR), and artificial intelligence (AI). Each of these innovations not only enhances operational processes but also introduces novel ways to engage users and facilitate access to information. As libraries continue to adapt, the successful integration of these technologies requires careful planning and consideration of their combined potential to transform library services.

i. Machine Learning and AI

Artificial intelligence and machine learning are rapidly changing library administration by automating complicated processes. AI-powered tools analyse user behaviour and classify resources to make recommendations tailored to the user's needs. For example, AI-driven solutions predict user needs by analysing search trends and offer personalised recommendations of resources that increase user interaction and satisfaction. Hanif et al. (2025) highlight how AI can be used in libraries to automate services, analyze usage data, enhance personalized user experiences, contribute to more strategic resource planning, and further enhance the analysis of data that

helps libraries in strategic resource allocation and collection optimization. To address ethical concerns, libraries should focus on developing transparent AI systems that ensure users are aware of how their data is being used. One effective approach could be integrating anonymisation techniques to protect user privacy, while still allowing for personalized services. Furthermore, libraries should develop user consent mechanisms to gain explicit permission before utilizing personal data, promoting transparency and trust.

ii. Blockchain Technology

Following the adoption of AI, blockchain technology is emerging as another vital tool in library management, particularly for secure data handling. Blockchain technology offers solid solutions for safe data management in libraries. Recent research by Hanif et al. (2025) emphasizes blockchain's role in securing patron data, enhancing transparency, and improving the reliability of digital lending systems in library environments. Libraries can ensure the confidentiality and integrity of patron records and digital rights management systems by implementing blockchain in practice. This system protects against unauthorised access to digital content and secures user information. Blockchain also facilitates the tracking of resource usage in a more transparent manner, which ensures reliability and accountability in digital lending processes (Yeh, Chen & Lin, 2021). Although blockchain presents significant potential, its implementation in smaller libraries or those with limited resources presents challenges, such as the need for skilled personnel and adequate funding. Libraries must develop strategies for overcoming these barriers, such as forging partnerships with technology providers or leveraging grants to access necessary expertise and infrastructure.

iii. Augmented and Virtual Reality (VR/AR)

Blockchain and AI are not the only transformative technologies currently being integrated into library systems. Augmented and Virtual Reality (VR/AR) offer immersive learning environments that can radically change the way users interact with library resources. While AR enhances physical spaces by overlaying digital information onto real-world environments, VR enables users to engage in entirely simulated experiences, such as virtual library tours or interactive educational activities. For instance, the University of Oklahoma Libraries has effectively integrated blockchain for secure online lending, while the National Library of Singapore uses AI to personalize catalog browsing. Similarly, the use of VR in academic libraries, such as those at Stanford University, allows students to explore historical sites or conduct scientific simulations remotely (Smith, Martzoukou & Reid, 2019). However, the adoption of AR/VR faces significant barriers, such as funding limitations and a lack of technical expertise, particularly in under-resourced libraries. To overcome these challenges, libraries can partner with local technology firms or academic institutions to share resources and pilot AR/VR initiatives on a smaller scale.

2.2 Evolving Roles of Libraries

The ongoing technological advancements are not only changing the tools libraries use but also transforming their core functions and the way they interact with their communities. The functions of libraries have dramatically changed from static information repositories to dynamic digital knowledge centres. Traditional libraries needed to acquire, catalogue, and preserve physical materials such as books and manuscripts. To keep up with technological advancement and user demand, libraries have adopted digital transformation to remain relevant in the modern information landscape. The implementation of cloud-based library systems that enable users to access materials at any time and from any location, the provision of e-books and digital journals, and access to extensive electronic databases are all examples of this change (Thompson & Riley, 2021).

Today's libraries are also learning centres, creativity incubators, and spaces for collaboration. Public libraries have become crucial in raising digital literacy through workshops, training courses, and maker spaces where users can practise coding, 3D printing, and multimedia creation. These areas nurture innovation and creativity by providing a forum for teamwork and building skills. In stark contrast, academic libraries are deeply integrated into the research and teaching frameworks, offering more programs such as embedded librarianship, which links library professionals directly with the academic departments to support research and curriculum development (Syed, 2019). As libraries continue to evolve, they must remain proactive in addressing the digital divide and ensuring that all users have equitable access to these transformative services, particularly those in under-resourced areas.

2.3 Open Access and Knowledge Sharing

With the advent of open-access platforms, accessibility to scholarly resources has come with minimum barriers; hence, wider dissemination of information has resulted worldwide. Other than conventional means of access, open access provides academic articles, journals, and databases free of cost to academics, educators, and the general public. This democratisation in knowledge facilitates international collaboration by removing info-silos around the globe, advancing equitable opportunities for education, and quickening scientific advancement. By managing institutional repositories that provide open access to faculty articles, theses, and other works of scholarship, libraries are key players in this phenomenon (Piwowar et al., 2018).

Cooperation between academic institutions and libraries has been one of the added advantages of marketing for digital repositories. There is close cooperation between universities, colleges, and their libraries in archiving and sharing academic outputs that will ensure its preservation and access over a long period. These collaborations include training academics regarding open-access procedures and facilitating legislation that allows unfettered access to publicly supported studies. Therefore, libraries act to narrow the gap between knowledge producers and consumers, making the culture of research and education inclusive and transparent (Yeh, Chen & Lin, 2021). While open-access models have seen success, barriers remain, particularly in terms of navigating copyright laws and securing sustainable funding. Libraries can address these challenges by advocating for policy changes, collaborating with open-access initiatives, and ensuring that content sharing is both secure and legally compliant.

2.4 Data-Driven Decision Making

With the rise of open access and collaborative knowledge sharing, libraries are also harnessing big data analytics to further refine their services and operational strategies. Big data analytics are done in libraries to inform user services and operations better. Based on data gathered and analysed regarding user behaviour, library resource usage, and service preferences, informed decisions can be made that optimise the resource allocation of investments and maximise user experiences. With these data-driven insights, for example, libraries can improve their holdings by forecasting future demand for materials and offering better user recommendations. Analytics also show the effectiveness of library services and events for adjustment using instant feedback, as stated by Johnson & Petersen (2019).

With the application of big data into libraries, however, ethical issues arise concerning security in data usage and users' privacy. As a large volume of personal data is collected through library systems, there is a possibility of increased breaches and misuse. Library organisations should be able to balance safeguarding users' rights to privacy while applying data to enhance services. Balancing trust in the user using data-driven techniques requires building proper data protections, open policies, and moral frameworks for data use (Borgman, 2020). Strategies to address these ethical concerns include implementing anonymisation techniques to protect user identities, ensuring that data is stored securely, and establishing transparent data usage policies that inform users of how their information is being utilized. Libraries can also introduce user consent mechanisms, allowing individuals to opt in or out of data collection, ensuring that they have control over their personal information.

3.0 Methodology

This methodology is based on a comprehensive review of peer-reviewed journal articles that examine the latest advancements and future directions in libraries within the context of emerging trends in information science. The approach is structured into three main components: a literature review, data synthesis, and future research opportunities.

The initial phase involved a meticulous selection of scholarly articles related to technological advancements and their application in library systems. Online academic platforms such as Scopus, World of Science, Emerald, Google Scholar, and Science Direct were utilized to identify relevant studies using keywords like "Emerging Library Trends," "Modern Library," "Digital Transformation in Libraries," "Library Technology Integration," and "Future Library Practices". Articles were selected based on specific criteria designed to ensure comprehensive and relevant coverage of the topic. First, relevance was prioritized, ensuring the article's focus on the roles of technology in transforming library services, as this was the central to the aim of understanding emerging trends in information science. This criterion ensured that only articles directly related to technological innovations, such as AI, blockchain, and VR, were considered. Second, recency was emphasized by prioritising publications from the last five years to align with cutting-edge trends. As technology evolves rapidly, researchers must examine the most current research to capture the latest advancements and the evolving landscape of libraries. Third, scholarly credibility was a key factor, with a preference for peer-reviewed articles and reputable journals. This criterion ensured that the selected studies were of high academic rigor and reliability, which is important for maintaining the integrity of the research. Peer-reviewed journals provide an additional layer of scrutiny and validation, making them an essential source for sound, evidence-based conclusions. Lastly, diversity of perspectives was considered, with researchers including articles from a range of library types such as academic, public, special, and geographical regions. By incorporating diverse sources, the review aimed to provide a more holistic view of how technological advancements are impacting libraries worldwide, accounting for different types of libraries, varying user needs, and regional technological infrastructure. This diversity ensured that the findings were not biased toward a specific region or type of library but instead a global, multifaceted understanding of trends. To ensure transparency, only studies meeting these criteria were included. The selection process was designed to minimise bias by focusing on high-quality, diverse sources. However, potential limitations exist, such as reliance on specific academic databases, which could exclude studies not indexed in the chosen platform or articles written in languages other than English. These limitations may introduce biases, which are acknowledged in the methodology.

The second stage of the methodology focused on synthesizing the insights from the reviewed articles to form general conclusions on the transformation of libraries in response to emerging trends in information science. This synthesis process involved several structured steps to ensure a thorough and systematic approach. First, a thematic analysis was performed to identify shared themes across the studies. This process involved carefully reading and coding each article to extract recurring topics related to technological integration in libraries such as AI, blockchain, and VR. Each theme was categorised into broader areas, such as technological applications, user experiences, library operations, and challenges faced by libraries. Once themes were identified, the next step was to assess the impact of these technological integrations. This involved examining how each technology influenced various library functions, such as resource management, user engagement, and service delivery. For instance, the integration of AI in cataloguing or blockchain in digital lending was evaluated for its effectiveness in improving operational efficiency and user satisfaction. Finally, the analysis focused on pinpointing gaps in the current literature. Articles that discussed emerging technologies but did not provide sufficient data were flagged for further exploration. This stage also highlighted opportunities for future research, such as areas where technological integration is still in its infancy or regions where implementation remains limited. By systematically categorising findings, comparing the data, and identifying areas lacking in-depth research, the synthesis aimed to offer a comprehensive view of the technological advancements transforming libraries while providing a roadmap for future studies. This detailed approach ensures replicability, as the steps and criteria for data analysis are clearly defined, allowing for consistent results when applied to similar research.

While the methodology provides a robust framework, the absence of primary data, such as surveys or interviews with library professionals, may limit the depth of practical insights, as the analysis is based solely on secondary sources. This may not fully reflect the lived experiences of library staff or regional variations in technological integration. Future research could benefit from incorporating empirical methods to validate findings or integrate real-world examples.

Overall, this methodology offers a systematic framework to explore how libraries are adapting to technological innovations, examining their potential for enhancing operations and addressing challenges, and provides a foundation for future research on the evolving role of libraries in the digital age and the practical implementation of emerging trends. The findings provide a foundation for future research on the evolving role of libraries in the digital age.

4.0 Findings

The findings from this study emphasize the profound impact of emerging technologies on the evolving roles and functions of libraries within the domain of information science. As libraries transition into the digital era, they are increasingly adopting advanced technologies such as artificial intelligence (AI), blockchain, and virtual/augmented reality (VR/AR). These technologies are reshaping how libraries manage resources, engage with users, and enhance access to information. This section explores these advancements, their implications, and the challenges faced by libraries in their implementation, providing a comprehensive understanding of the future of libraries in a rapidly evolving information landscape.

4.1 The Transformative Role of Emerging Technologies in Libraries

Emerging technologies have significantly expanded the capabilities of libraries, moving them beyond their traditional roles as repositories of physical materials. Libraries today are dynamic centers of technology, education, and community engagement. AI, blockchain, and VR/AR have proven to be transformative tools in library operations:

i. Artificial Intelligence (AI)

AI has revolutionized library management by automating complex processes and enhancing user experiences. AI-driven tools enable libraries to analyze user behavior and provide personalized services, such as tailored resource recommendations. For example, AI has been successfully implemented at the National Library of Singapore, where interactive catalogues and personalized book suggestions enhance user engagement. Smaller libraries, like the Kanawha County Public Library in West Virginia, are exploring AI chatbots to assist users with queries and provide recommendations, demonstrating the flexibility of AI to serve both well-resourced and under-resourced institutions. These examples illustrate the scalability of AI across diverse library types and sizes, offering transformative potential even for rural or smaller-scale libraries. Furthermore, machine learning algorithms assist in cataloging and classification, streamlining operations, and improving accuracy in ways that reduce staff workload and enhance the user experience. Additionally, predictive analytics allows libraries to anticipate user needs, optimize resource allocation, and plan strategic developments effectively. AI's potential becomes even more impactful when integrated with other technologies, such as blockchain, to enhance data security and personalization. For instance, AI can utilize blockchain-verified user data to deliver more accurate and trusted personalized recommendations, offering a seamless and secure user experience.

ii. Blockchain Technology

Blockchain offers robust solutions for secure data management and digital rights protection. Libraries utilize blockchain to safeguard user data, ensure the authenticity of digital resources, and track resource usage transparently. For instance, the University of Oklahoma Libraries has implemented blockchain for secure online lending, ensuring resource integrity and user privacy. Blockchain's potential extends to smaller or rural libraries, such as the Masiphumelele Library in South Africa, where it can facilitate transparent resource sharing across regional networks, empowering underserved communities. These applications underscore the versatility of blockchain in addressing challenges like security and access inequities across libraries of varying scales and settings. Blockchain's integration with AI opens new possibilities, such as ensuring the transparency and reliability of AI algorithms by recording and verifying their training data. This synergy can help libraries deliver personalized services while maintaining trust and accountability. Additionally, combining blockchain with AR/VR technologies can enable secure and rights-protected access to digital archives and immersive educational content, expanding the reach of these innovative tools.

iii. Virtual and Augmented Reality (VR/AR)

VR and AR technologies create immersive learning environments that transform the traditional library experience. These tools enable users to engage with content interactively, offering virtual tours, augmented exhibitions, and simulated learning activities. For instance, AR is used in school libraries in rural India to bring textbooks to life through interactive overlays, providing students with engaging and transformative educational experiences despite limited resources. Similarly, academic libraries, like those at Stanford University, integrate VR to allow students to explore historical sites or conduct scientific simulations remotely, offering unparalleled learning opportunities. The integration of AR/VR with AI-driven personalization further amplifies their impact. For example, AI can analyze user preferences and create customized AR/VR experiences, tailoring content to individual learning styles or interests. A library user exploring a VR recreation of historical sites could receive AI-guided tours, customized based on their prior searches and preferences. This interplay between technologies ensures that immersive environments are not only engaging but also highly relevant and impactful for users. By integrating VR/AR with other tools like blockchain, libraries can ensure the secure distribution and protection of digital content, enabling libraries to expand their reach while maintaining inclusivity and accessibility.

4.2 Challenges in Technology Adoption

While emerging technologies present immense opportunities, their adoption comes with significant challenges. Libraries face several barriers in implementing and sustaining these innovations, particularly in smaller and rural institutions. The table below summarizes the key challenges libraries face in adopting emerging technologies, along with suggested strategies for overcoming them.

Table 1. Challenges libraries face in adopting emerging technologies

Challenge	Description	Suggested Strategies
Limited Budget	High costs of acquiring and maintaining technologies like AI, blockchain, and VR/AR pose barriers for underfunded libraries.	Explore grant funding, NGO partnerships, public-private models, or crowd-funding initiatives.
Digital Divide	Urban libraries often have better access to technology than rural or underserved areas, limiting equal access to digital services.	Mobile tech units, government-supported infrastructure upgrades, and community digital literacy programs.
Balancing Traditional and Digital Services	Need to serve both digital-savvy users and those preferring traditional physical resources while avoiding alienating either group.	Dual-format service models, staff cross-training, and responsive user feedback systems.
Interconnections Between Trends	Technologies such as AI, blockchain, and VR/AR increasingly interlink, requiring integrated approaches to maximize benefits.	Invest in integrated tech solutions and staff upskilling for combined technology applications.
Gaps in Current Research	Most studies focus on large academic libraries, leaving small or rural libraries underrepresented in discussions of tech adoption.	Promote user-centered and rural-focused research, including case studies, surveys, and exploratory programs.
User Perspectives on Emerging Library Technologies	Diverse user groups (seniors, children, and disabled users) face unique challenges due to interface design, accessibility, or digital literacy gaps.	Accessible interfaces, digital literacy workshops, gamified content for youth, inclusive tech (e.g., screen readers, voice commands).

i. Limited Budgets

The limited budget is one of the key problems that libraries encounter when adopting most of the existing and emerging technologies. New technologies such as AI, blockchain technology, virtual reality, and even augmented reality come with a large investment both in terms of their procurement and their maintenance. Smaller libraries, like those in rural Kenya, have overcome budget constraints by partnering with NGOs like the EIFL (Electronic Information for Libraries) to fund pilot technology projects. Public-private partnerships, such as those seen in Germany's community libraries, also provide a viable model to share costs. Exploring crowd-funding campaigns or "adopt-a-library" programs can further alleviate financial pressures.

ii. Digital Divide

The availability of library services equally also has limitations in the digital aspect. Over the years, where there has been economic growth in the cities, libraries in those settings have advanced technological equipment compared to those in the rural areas where it is difficult to find even basic digital services. This divide creates barriers to information and chances, especially in vulnerable societies (Ekeng & Esin, 2021). To address this divide, libraries can develop mobile units equipped with technology resources, such as those initiated by the "Libraries on Wheels" program in rural Pakistan. These efforts bring library resources to underserved communities, reducing barriers to access.

iii. Balancing Traditional and Digital Services

A further major hurdle is the need to maintain conventional library services on the one hand and the upsurge in the desire for digital resources on the other hand. Many people love the idea of digital services like e-books or online databases; however, some still appreciate physical books and the assistance of a librarian. Libraries need to address the needs of such users as well, meaning that they must provide access to traditional resources while increasing their digital ones too. Staff training programs, such as those implemented in Denmark's public libraries, provide librarians with the skills to navigate and promote both physical and digital services effectively.

iv. Interconnections Between Trends

Emerging technologies in libraries tend to converge and therefore, maximise benefits. For example, artificial intelligence relies on big data and its analytical capabilities, as it requires the data to create algorithms that learn client behaviour to suggest products they like, even before they require it. This makes it more convenient and fulfilling for the clients as they are offered customised services. In addition to this, blockchain can be used alongside open-access policies to protect digital content from loss, damage, or any kind of breach. It goes on to protect original content and exercise control over its use, so verse content can be published and accessed by the relevant parties (U.S. Copyright Office, n.d) Such functionality of these technologies will help enhance library services to achieve even higher levels of efficiency, security, and personalization.

v. Gaps in Current Research

Amidst the expanding corpus of explorations on library technology, certain significant domains are still under-researched. One noteworthy aspect is the little attention focused on small-sized libraries, especially those located in rural or marginalised communities. Most of the research involves large academic libraries or urban public ones with plenty of resources, yet small-sized libraries encounter additional problems in the embrace of these technologies including among other aspects funding and lack of technical know-how. Literature that addresses these issues of technology adoption including the barriers faced and the interventions that have been employed would greatly inform the discourse of how even the relatively smaller library can be digitised (Haleem et al., 2022). To address these gaps, future studies could explore specific strategies for small libraries to overcome these challenges. For example, research could focus on innovative funding models, such as public-private partnerships, grant programs tailored to rural libraries, or collaborative resource-sharing networks. Additionally, case studies documenting successful technology adoption in small or rural libraries would provide practical frameworks for other institutions facing similar limitations. These studies could highlight cost-effective solutions, such as open-source software, mobile technology platforms, or community-based training programs that equip library staff and users with necessary digital skills.

Still another concept in this field where research has been minimal concerns the attitudes and beliefs of users towards new tools and services available in libraries. It appears that studies have concentrated on the components of AI, VR, and Blockchain technologies rather than how various users, especially those from different backgrounds or with low computer literacy levels, would embrace such technologies. To address this gap, it is essential to conduct user-centric studies that investigate the diverse experiences of library patrons. Research could explore how demographic factors, such as age, socioeconomic status, and education level, influence technology adoption. For instance, targeted studies on how rural communities, seniors, or users with disabilities interact with digital library services could yield actionable insights for improving accessibility and inclusivity. Surveys, focus groups, and pilot programs could help capture user feedback and inform the design of more user-friendly technologies. Grasping user attitudes is important as this will help libraries create services that do not discriminate against or exclude any user and that are useful to everyone (Ekeng & Esin, 2021). Moreover, additional research should examine the role of library staff in bridging the gap between technology and users. Investigating the training needs and challenges faced by staff members in implementing emerging technologies would help design targeted professional development programs. By addressing these research gaps with specific, actionable recommendations, libraries can enhance their ability to serve diverse communities and ensure equitable access to technological advancements.

vi. User Perspectives on Emerging Library Technologies

Senior citizens have particular difficulties using library services because of the digital literacy gap, which can make using e-book platforms and online catalogues difficult. Small text sizes, complicated interfaces, and a lack of accessibility features like voice-assisted tools are problems for many seniors, while psychological obstacles like humiliation and anxiety make participation even more difficult. By providing seniors with specialised digital literacy workshops that teach them how to use library technologies efficiently, creating user-friendly interfaces with larger fonts and easier navigation, and integrating assistive technologies like voice controls or screen readers to improve accessibility and usability, libraries can address these problems.

In addition to senior citizens, children and young adults also face unique challenges when engaging with library technologies. For instance, children require age-appropriate, engaging interfaces that support early literacy and cognitive development. Libraries can adopt gamified platforms and interactive tools to foster learning and maintain their interest. An example of this is the use of AR apps in school libraries to bring educational content to life through gamified interactions. Similarly, young adults may benefit from resources tailored to their academic and professional growth, such as online career guidance tools or AI-driven platforms that recommend relevant study materials or job opportunities.

Users with disabilities, another critical demographic, often encounter barriers when accessing library technologies. Individuals with visual impairments, for example, require assistive technologies such as screen readers, Braille displays, or voice-command functionalities. Libraries can also implement AR features designed for users with hearing impairments, offering visual cues or real-time subtitles during virtual events or workshops. Initiatives such as these make libraries more inclusive and accessible, ensuring equitable access to resources and services.

Additionally, the perspectives of library staff, who play a crucial role in implementing and managing these technologies, are essential. Staff members often require extensive training to adapt to emerging tools and ensure smooth integration into library operations. Providing professional development programs, such as workshops on AI integration or blockchain-based resource management, equips staff with the skills necessary to handle new technologies effectively. Beyond training, it is vital to address staff concerns regarding workload and technology adoption, as these factors influence their ability to serve users effectively.

By considering the perspectives of diverse demographics including children, young adults, users with disabilities, and library staff—libraries can ensure their services are inclusive and impactful, meeting the needs of all users in a rapidly changing technological landscape.

5.0 Discussion

5.1 The Transformative Role of Emerging Technologies in Libraries

i. Artificial Intelligence (AI)

To address the challenges and optimize the use of AI in libraries, several strategies and recommendations can be implemented. Libraries should prioritize the integration of AI-driven tools that support personalized user experiences and streamline cataloging processes. For instance, The New York Public Library (NYPL) has successfully implemented an AI-powered recommendation engine that analyzes users' borrowing history and preferences to suggest new books, improving engagement by delivering personalized content. Additionally, the University of Michigan Library uses AI algorithms to automate the cataloging and classification of its digital collections, reducing manual labor and increasing the accuracy of resource organization.

Smaller libraries, such as the Chattanooga Public Library, have also integrated AI tools like OCLC's Wise for personalized services and digital collection management. To optimize AI implementation, libraries can collaborate with AI developers to create customized solutions suited to their needs. The British Library, for example, has partnered with AI companies to enhance its digital cataloging systems, integrating machine learning to improve metadata accuracy and automate the organization of new acquisitions. Additionally, Training programs for library staff, focusing on ethical and functional aspects of AI, can strengthen human-AI collaboration. Importantly, ethical concerns, particularly data privacy and algorithmic bias, must be addressed proactively. As noted by Gupta et al. (2023), AI systems in information services must be regularly audited to ensure fairness and transparency.

In the future, libraries should advocate for open-source AI solutions that can reduce costs and increase access for smaller institutions. Open-source projects, such as Vufind (an open-source discovery layer), enable libraries to build customized cataloging and

recommendation engines without the high costs typically associated with proprietary systems. In conclusion, while AI offers significant potential to streamline operations and enhance user experiences, libraries must carefully navigate the ethical challenges associated with its implementation to ensure fairness, inclusivity, and transparency in its use.

ii. Blockchain Technology

To fully harness the potential of blockchain technology, libraries should focus on strategies that enhance security, transparency, and trust. One approach is to develop blockchain-based platforms for secure digital lending and copyright protection. Libraries can partner with technology firms to co-develop blockchain infrastructure suited for library needs. They should also establish clear guidelines and protocols for the use of blockchain in data protection and transaction tracking. To promote future sustainability, libraries should participate in collaborative research projects on blockchain applications in information science. By doing so, they can contribute to the development of standards that ensure the interoperability of blockchain solutions across library systems. Abid (2021) discusses various applications of blockchain in library services, highlighting its potential in digital preservation, interlibrary loans, and credential verification. The study emphasizes that blockchain can help libraries manage and share authoritative information securely and efficiently.

iii. Virtual and Augmented Reality (VR/AR)

To fully capitalize on VR/AR technology, libraries should adopt a phased implementation strategy. Initially, libraries can introduce VR/AR in educational programs, such as virtual tours of historical sites or interactive learning experiences. Furthermore, virtual libraries in platforms such as Meta Horizon Worlds have shown potential for creating inclusive and interactive environments. Hollister (2024) found that virtual community libraries not only support digital literacy but also facilitate social engagement and access to library services in geographically remote areas. Such examples illustrate how VR can extend a library's reach beyond its physical boundaries. Partnerships with educational institutions and technology providers can help libraries acquire VR/AR resources at lower costs. To ensure future adaptability, libraries should develop user training sessions and workshops that teach patrons how to use VR/AR tools. Moreover, libraries can engage in research collaborations to create new VR/AR content tailored to library needs. Such efforts will establish libraries as innovative learning hubs that embrace experiential and immersive learning opportunities.

5.2 Recommendations on Challenges in Technology Adoption

i. Limited Budgets

To overcome budget constraints, libraries should explore alternative funding strategies. Establishing partnerships with technology providers and private sector organizations can reduce the financial burden of acquiring emerging technologies. Libraries can also apply for government grants or international funding programs aimed at supporting digital transformation. Another approach is to adopt a phased implementation plan, prioritizing cost-effective technologies with the highest impact on user experience. For future sustainability, libraries should advocate for increased public funding and support from community stakeholders. Involving the local community in fundraising initiatives or donation drives could also provide an additional financial boost.

ii. Digital Divide

Bridging the digital divide requires libraries to adopt proactive outreach strategies. Mobile library units equipped with digital devices can bring technology to remote and underserved communities. Libraries can also collaborate with technology companies to donate used but functional digital devices to rural libraries. However, the digital divide is deeply rooted in infrastructure issues and systemic inequalities that extend beyond just access to devices and the internet. Libraries must advocate for policies and investments that improve broadband infrastructure, especially in underserved regions, ensuring that all communities, regardless of location, can access reliable digital services.

Additionally, systemic inequalities such as low-income households, limited access to quality education, and lack of digital skills further contribute to the divide. Libraries can address these issues by offering tailored community-based training programs focused on digital literacy. These programs can empower users, especially in marginalized communities, to better navigate the digital world and make use of online services. Advocacy for government support and policy changes can secure more funding to improve digital infrastructure in rural areas, while also addressing the broader societal issues that limit access to technology.

To ensure future inclusivity, libraries should develop long-term strategies that prioritize equitable access to technology for all communities. This includes not only delivering devices but also creating a lasting support system through digital literacy training, policy advocacy, and sustained efforts to improve local infrastructure. By addressing the root causes of the digital divide such as infrastructure limitations and systemic inequalities libraries can take a comprehensive approach to bridging this gap and ensuring more equitable access to technology for future generations.

iii. Balancing Traditional and Digital Services

To balance traditional and digital services, libraries should adopt a hybrid model that allows seamless access to both physical and digital resources. Strategies include offering on-demand digitization of physical books and promoting the use of both e-books and hard copies. Libraries can also develop comprehensive user feedback systems to understand user preferences and improve resource allocation accordingly. To future-proof their services, libraries should focus on creating flexible service models that can adapt to changing user demands. This might involve cross-training library staff to support both traditional and digital service delivery, ensuring a smooth transition as user needs evolve.

iv. Interconnections Between Trends

Addressing the interconnections between emerging technologies requires an integrated approach. Libraries should create a unified technology strategy that ensures cross-platform compatibility between AI, blockchain, and VR/AR systems. Establishing cross-disciplinary teams with expertise in these technologies can lead to better system integration and more cohesive user experiences. Collaborations with universities, technology providers, and research institutions can result in the development of innovative solutions. In

the future, libraries should prioritize ongoing research and development efforts focused on the convergence of emerging technologies. This will ensure that libraries remain at the forefront of technological innovation.

v. Gaps in Current Research

Closing research gaps requires a concerted effort to address the unique challenges faced by smaller libraries and marginalized communities. Libraries should advocate for more inclusive research that captures the experiences of underrepresented library systems. Conducting user studies to understand the needs of rural libraries and their users can provide insights into effective interventions. Libraries should also establish partnerships with academic researchers to co-develop case studies on successful technology adoption in smaller institutions. Looking to the future, libraries should prioritize collaborative research projects that explore user perspectives, emerging trends, and best practices for technology adoption in libraries of all sizes.

vi. User Perspectives on Emerging Library Technologies

To address user perspectives, libraries should prioritize user-centered design principles when developing new technology-based services. Engaging users in the design process through participatory design workshops can result in more user-friendly systems. These workshops could involve gathering feedback through surveys, focus groups, and usability testing, where users actively contribute to the design process. Libraries should also focus on creating accessible technologies, such as voice-controlled interfaces and larger font sizes, to better serve elderly patrons and users with disabilities. Offering tailored digital literacy training programs for seniors can enhance their confidence in using digital services. For future sustainability, libraries should establish feedback loops where users can provide continuous input on the accessibility and usability of emerging technologies. This can be done by incorporating user feedback systems like in-app surveys, comment boxes, or user experience interviews. Additionally, libraries can use analytics tools to track user behavior and identify areas where users face difficulties or express dissatisfaction. Once this data is collected, it should be analyzed regularly to detect patterns and inform design decisions. Libraries can act upon this feedback by implementing improvements to interfaces, adding new features, or adjusting existing ones to better meet users' needs. By ensuring that the feedback loop is ongoing, libraries can keep refining their services to remain inclusive and relevant, ultimately enhancing the user experience and fostering greater engagement with technology.

6.0 Conclusion

In conclusion, artificial intelligence (AI) is transforming libraries from static knowledge repositories into dynamic, tech-driven hubs. This review highlights AI applications like personalized cataloging, automated classification, and recommendation systems that improve user engagement and service efficiency. Alongside AI, technologies such as blockchain and VR/AR are broadening library roles in education and community engagement, ensuring secure digital asset management and immersive learning experiences.

Despite challenges like limited funding, the digital divide, and balancing traditional services, libraries are adapting through strategic partnerships and innovative solutions. Their continued evolution supports digital literacy, lifelong learning, and equitable access to resources. Ultimately, AI and emerging technologies position libraries as vital facilitators of knowledge and societal progress in the digital age.

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Paper Contribution to Related Field of Study

This article contributes to the field of Information Management as described in the introduction.

References

- Abid, H. (2021), "Uses of blockchain technologies in library services", Library Hi Tech News, Vol. 38 No. 8, pp. 9-11. <https://doi.org/10.1108/LHTN-08-2020-0079>
- Borgman, C. L. (2020). Big data, little data, or no data? Why human interaction with data is a hard problem. In Proceedings of the 2020 Conference on Human Information Interaction and Retrieval (CHIIR '20) (p. 1). Association for Computing Machinery. <https://doi.org/10.1145/3343413.3377979>
- Dhar, P., Rocks, T., Samarasinghe, R. M., Stephenson, G., & Smith, C. (2021). Augmented reality in medical education: students' experiences and learning outcomes. Medical Education Online, 26(1). <https://doi.org/10.1080/10872981.2021.1953953>
- Ekeng, M. E., & Esin, J. E. (2021). Users' satisfaction with library facilities and attitude of staff in National Library. DigitalCommons@University of Nebraska - Lincoln. <https://digitalcommons.unl.edu/libphilprac/6012>
- Gupta, S., Patel, K., & Keshav, S. (2023). Bias in AI recommendation systems in digital libraries: A systemic review. Information Processing & Management, 60(2), 102-121.

- Hanif, S., & Ali Shah, S. A. (2025). "Blockchain Technology in Libraries: Ensuring Data Security and Transparency." https://www.researchgate.net/publication/389494534_BLOCKCHAIN_TECHNOLOGY_IN_LIBRARIES_ENSUREING_DATA_SECURITY_AND_TRANSPARENCY
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285. <https://doi.org/10.1016/j.susoc.2022.05.004>
- Hollister, J. M. (2024). Virtual Libraries in the New Metaverse: An Exploratory Study on Community Libraries in Meta Horizon Worlds. *International Journal of Knowledge Content Development & Technology*, 14(1). <https://ijkcdt.net/xml/42804/42804.pdf>
- Johnson, M., & Petersen, C. (2019). Data-driven decision making in libraries: Improving user services and resource management. *Library Management*, 40(9), 801–810.
- Piwowar, H., Priem, J., Lariviere, V., Alperin, J. P., Matthias, L., Norlander, B., Farley, A., West, J., & Haustein, S. (2018). The state of OA: A large-scale analysis of the prevalence and impact of Open Access articles. *PeerJ*. <https://doi.org/10.7717/peerj.4375>
- Smith, J., Martzoukou, K., & Reid, P. (2019). Augmented reality and virtual reality technologies in libraries: Applications and opportunities. *Library Hi Tech*, 37(3), 387–402
- Syed, J. (2019). Embedded librarianship: Strengthening academic libraries' role in research and teaching. *Journal of Academic Librarianship*, 45(3), 210–218.
- Tait, E., Martzoukou, K., & Reid, P. (2016). Libraries for the future: The role of IT utilities in the transformation of academic libraries. *Nature News*. <https://www.nature.com/articles/palcomms201670>
- Thompson, G., & Riley, P. (2021). Digital transformation in libraries: How libraries are embracing new technologies. *Library Management*, 42(5), 123–139.
- U.S. Copyright Office. (n.d.). What is Copyright? | U.S. Copyright Office. <https://www.copyright.gov/what-is-copyright/>
- Yeh, P. W., Chen, J., & Lin, W. (2021). Blockchain applications in libraries: A systematic review. *Journal of Library & Information Science Research*, 42(4), 55–67