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THE TRANSFORMATIVE ROLE OF ARTIFICIAL INTELLIGENCE IN OPTIMIZING LIBRARY SYSTEMS AND SERVICES

O PAPEL TRANSFORMADOR DA INTELIGÊNCIA ARTIFICIAL NA OTIMIZAÇÃO DE SISTEMAS E SERVIÇOS DE BIBLIOTECAS

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Abstract
Integrating AI in library systems has transformed its infrastructure into advanced management, contributing to operational efficiency and user experience. Meanwhile, several studies mentioned the application of AI in library management through advanced technologies. However, this research aimed to assess the role of artificial intelligence (AI) in library management systems to enhance user experience (UE), operational efficiency (OE), and services. The research adopted a mixed method, incorporating a semi-structured interview and survey questionnaire (20 items) distributed across 500 participants (users and librarian staff). The semi-structured interviews were based on three themes, including personalized services, challenges, operational efficiency, and information accessibility. The findings revealed a strong positive correlation between AI and OE (0.902) and UE (0.791). Moreover, the user responses indicate a positive influence of AI on user perception due to personalized recommendations, operational efficiency, and information accessibility, along with challenges to utilize. Future research studies should explore the aspect of AI in accessing and operating

Resumo
A integração da IA em sistemas de bibliotecas transformou sua infraestrutura em uma gestão avançada, contribuindo para a eficiência operacional e a experiência do usuário. Diversos estudos mencionaram a aplicação da IA na gestão de bibliotecas por meio de tecnologias avançadas. No entanto, esta pesquisa teve como objetivo avaliar o papel da inteligência artificial (IA) em sistemas de gestão de bibliotecas para aprimorar a experiência do usuário (UE), a eficiência operacional (EO) e os serviços. A pesquisa adotou um método misto, incorporando uma entrevista semiestruturada e um questionário (20 itens) distribuídos entre 500 participantes (usuários e bibliotecários). As entrevistas semiestruturadas foram baseadas em três temas, incluindo serviços personalizados, desafios, eficiência operacional e acessibilidade à informação. Os resultados revelaram uma forte correlação positiva entre IA e EO (0,902) e UE (0,791). Além disso, as respostas dos usuários indicam uma influência positiva da IA na percepção do usuário devido a recomendações personalizadas, eficiência operacional e acessibilidade à informação, além de desafios de utilização. Pesquisas futuras devem explorar o aspecto da IA no acesso e na

knowledge through personalized training, campaigns, and awareness sessions.

Keywords: Artificial Intelligence. Library Systems. Operational Efficiency. User Experience. Digital Transformation.

operação do conhecimento por meio de treinamentos, campanhas e sessões de conscientização personalizados.

Palavras-chave: *Inteligência Artificial. Sistemas de Biblioteca. Eficiência Operacional. Experiência do Usuário. Transformação Digital.*

1 INTRODUCTION

Technological emergence in the 21st century has influenced numerous disciplines, departments, and public service sectors thriving within communities, in particular, it has transformed the aspect of managing services across public libraries. Modernization has transformed the library's service infrastructure, which has led to enhancing service quality, inclusivity, and diversity. Libraries, through decades, have been a central knowledge hub, storing ancient archives and historical narratives for future generations [1]. Conventional libraries have provided a profound physical knowledge collection, including books, historical records, and academic sources. Currently, these libraries have implemented service digitization, facilitating knowledge acquisition through digital books. [2]. Thus, libraries have evolved as digital space hubs and advancements, which also involve the apt inclusion and usage of AI, due to the growing trend in innovative approaches [3]. However, effective management of the library system has come forth as a strategy to efficiently digitize library services, thus enhancing access to users across the globe. AI is adopted within the library management system to address individual needs and likewise, enhance the experience of the user. The management system thus implements AI-led strategies to promote efficient data storage, maintenance, and resource operations, alongside advancing knowledge [4,5].

AI is a cataloging system that facilitates the categorization and automation of resources for managing libraries [6]. Moreover, AI-assisted technologies boost personalized recommendation services to streamline the management of metadata and manage knowledge retrieval systems. Additionally, these tools assist in encouraging user-centric library design through automated text analysis and intelligence information classification [7]. Such library services are updated by incorporating AI tools for automated and predictive analysis, which predict the preferences and needs of users, providing personalized recommendations through machine learning [8, 9, 10].

Similarly, AI-assisted tools encourage the utilization of digital services in libraries by recommending browsing that leverages the satisfaction of users [11] and develops efficiency in library management services [12, 13]. Furthermore, Ali *et al*. (2020) advocated the apt implementation of AI-assisted tools for user-centered services within libraries, including machine learning approaches, for instance, natural language processing, pattern recognition, chatbots, and cloud computing to retrieve information [14, 15, 16, 17, 18].

Additionally, studies have demonstrated the application of several AI-assisted tools and strategies in anticipating library resource demands and service delivery to enhance user satisfaction and operational efficiency. The major advancements involving NLP, data analytics, and intelligent recommendations contribute to efficient library operations to enhance user experience [19]. Despite these advancements, significant research gaps persist, warranting further exploration and analysis of AI integration for efficient library operations. For instance, studies abound on the technical aspects of AI analytics, and more research is needed to examine its technological trends in user engagement, satisfaction, and experience [20]. However, the current study focused on the role of AI in transforming approaches for library operations to provide extensive literature with research analysis. In addition, the research provided insights into the application of AI in increasing library services for information accessibility and user experience. Moreover, the study highlighted the adoption of AI in overcoming the limitations of traditional libraries to satisfy users' needs with respect to modern society.

2 RESEARCH OBJECTIVE

1. To assess the AI’s role in managing library services to enhance library user experience and operational efficiency.

3 LITERATURE REVIEW

Several existing research studies elucidate AI’s conceptual standing and technological advancement in digitalizing conventional libraries and establishing dynamic digital environments to alleviate the experiences of library users. For instance, AI and blockchain technology aid in enhancing resource allocation with information

accuracy within libraries, which boosts service quality through data-driven processes and personalized recommendations [21]. Recently, AI has garnered significant attention from stakeholders across diverse disciplines due to its advanced features. AI also contributes to numerous industries, including healthcare services for early disease detection and diagnosis. Furthermore, it also facilitated health monitoring to improve life quality and medical advancements [22]. Shah and Chircu (2018) also discussed the application of AI in the health sector for disease monitoring, patient care, and treatment procedures [23].

However, Dwivedi *et al*. (2019) highlighted that AI has transformed processing activities in each industry for social and intellectual applications. Similarly, the research emphasized the impact of AI across a diverse range of industries, including finance, logistics, supply chain, and manufacturing, through machine learning algorithms [24]. Likewise, AI contributes in the academic domain, providing extensive knowledge that enables operational efficiency and user interactions within libraries [25, 26]. Manjunatha (2023) explained that AI-based libraries offer multiple advantages in enhancing the library's operational and management system by developing user interaction for user experience. The AI-assisted services in libraries include wide access to information and personalized recommendations according to users' preferences for their satisfaction [27, 28,29]. Additionally, library services are enhanced through AI-assisted strategies, including natural language processing (NLP) and machine learning (ML), to enhance accessibility and accuracy of information retrieval. Users can search for information across broad resource access in libraries through an AI-driven approach [30,31]. Therefore, AI-assisted technologies positively impact library management systems by delivering relevant information for user-centered services. Besides these, AI, including blockchain, also ensures data confidentiality in managing library systems and developing user engagement and trust by securing data [32,33].

Furthermore, research demonstrated the positive impact of AI in libraries, enhancing users’ satisfaction and experience through personalized recommendations [34]. The AI-based recommendations have been provided by analyzing users' behavior and preferences to satisfy their needs. AI facilitates personalized and user-centric services by assessing user preferences through predictive tools to increase user satisfaction and engagement, establishing an interactive library environment [35]. However, massive data have been managed by adapting AI that has been transformed into digital libraries. It provides broad information accessibility to users so that they can store massive amounts

of knowledge, leading to intellectual resources. The advanced features of AI enable the development of robust and novel knowledge collection, satisfying academic needs and improving users' engagement. The meta-directed AI shifts library services and management into an advanced system that results in user-centered services [36]. These studies demonstrated the positive impact of AI on the library's operational efficiency and user experience due to high interaction, engagement, and satisfaction levels. Meanwhile, the majority of studies discussed the influence of AI across various library characteristics that need analytical research for accuracy in examining the influence of AI on library services and user experience.

4 METHODOLOGY

The current research adopted a mixed-method research design and employed a qualitative and quantitative approach to assess the role of artificial intelligence (AI) in library operational efficiency (OE) and user experience (UE). Similarly, Dwadi *et al*. (2021) emphasized that the mixed-method research design facilitated exploring and analyzing respondents' perceptions to address research objectives with accurate and valid results [37].

5 ETHICAL CONSIDERATION

The participants were informed regarding the research protocols by explaining the objectives and procedures prior to interviews and surveys. Participants were assured of confidentiality and personal information by focusing on security and privacy. Moreover, the research sought approval from the library organizations for a valid and ethical data collection procedure.

6 PARTICIPANTS

In addition, this study included 500 participants (users and librarian staff) selected through a random sampling technique. Moreover, the participants were conveniently selected from one academic and city library within a similar region. However, a large sample size was selected to ensure reliable result outcomes and extensively address the

influence of integrating AI on the library's operational efficiency and user experience. Furthermore, the research intended to explore the role of AI across multiple areas by selecting diverse age groups (21-50). Moreover, a few participants were interviewed through semi-structured questions to investigate the role of AI-based library services in their experience with respect to their perceptions.

Subsequently, the survey questionnaire was based on 20-items that were distributed among participants in order to analyze AI role in library's operational efficiency (OE) and user experience (UE). These 20-items in survey were comprised of three constructs including Role of Artificial Intelligence (AI), Operational Efficiency (OE), and User Experience (UE). The first construct "Role of Artificial Intelligence (AI)" involved 6 items that were adopted from Fabunmi and Akinyemi (2024) [38]. Whereas the Operational Efficiency (OE) construct included 7 items adopted by Hervieux and Wheatley (2020) [39]. On the contrary, the User Experience (UE) construct included 7 items adopted from Shaheen and Khurshid (2023) [40].

7 DATA COLLECTION

The survey questionnaire was electronically distributed to 500 customers as participants for qualitative response and quantitative analysis. However, the participants were given two months to conclude their responses. The responses were scored through the Likert scale, and items no 1-6, 8-13, and 15-19 were categorized as follows:

1. Very Unlikely- 1 2. Moderately Unlikely-2 3. Slightly Unlikely-3 4. Slightly Likely-4 5. Very Likely-5

However, item no. 7 and 14 were categorized as:

1. Never 2. Rarely 3. Often- 4. Always

Moreover, item no 20 was comprised as follows:

1. Unsatisfied, 2. Slightly Satisfied, 3. Moderately Satisfied, 4. Very Satisfied 5. Extremely Satisfied

Additionally, to avoid ambiguity, retrieved responses with missing data were excluded. Later, the reliability and validity of the survey questionnaire were measured through Cronbach's Alpha reliability analysis.

8 QUESTIONNAIRE RELIABILITY AND VALIDITY

Questionnaire reliability and validity are essential to evaluate and conduct efficient and effective research. Reliability and validity are considered effective methods for analyzing the questionnaire and ensuring the precise apprehension of intended information [41].

Table 1:

Questionnaire Reliability and Validity

Cronbach's Alpha	N of Items
0.908	20

Source: Authors

Generally, the most acceptable Cronbach alpha value is 0.9 or above, which is considered excellent reliability. However, the questionnaire item's Cronbach Alpha value is 0.908, which is considered generally reliable and suitable for most research purposes, hence indicating high internal reliability.

9 DATA ANALYSIS

The data was collected within two months, and the survey questionnaire was emailed to the participants across academic and city libraries. The researcher utilized an online survey platform, allowing a high response rate, follow-up reminders, and anonymous responses to ensure a result in authenticity. Following data collection, the responses were analyzed through SPSS to assess the responses through descriptive statistics and correlation analysis.

Moreover, the qualitative assessment involved semi-structured interview questions, providing a transparent overview of library users' perceptions, attitudes, and experience levels with AI-based library services. The responses from the qualitative data were gathered to develop themes for prospective thematic analysis, exploring users' experiences with implementing AI-based library services. In addition, the participants' responses were encoded and transcribed to assess recurring concepts and ideas stated by the respondents.

10 RESULTS

10.1 Quantitative Analysis

Table 2:

Demographic Statistics of Participants

Statistics		
	Gender	**Age**
Valid N	500	500
Mean	1.50	2.22
Std. Deviation	0.500	0.757

Source: Authors

Table 2 shows the demographic statistics of participants, indicating a 1.50 ± 0.500 average of gender and a 2.22 ± 0.757 average of age. This referred to the highest mean of age, while the lowest mean was of gender.

Table 3:

Descriptive Statistics of Gender

		Frequency	**Percent**
Valid	**Male**	251	48.3
	Female	249	47.9
	Total	500	96.2
Missing	**System**	0	0
Total		520	100.0

Source: Authors

Table 3 demonstrates descriptive statistics of gender, including 251 males and 249 females. A total of 48.3% of males were included, whereas 47.9% of females were involved in the research. This indicates a slightly equal number of males and females due to 100% frequency, reducing gender biases.

Table 4:

Descriptive Statistics of Age

		Frequency	**Percent**
Valid	**21-30**	100	19.2
	31-40	190	36.5

	41-50	210	40.4
	Total	500	96.2
Missing	**System**	0	0
Total		520	100.0

Source: Authors

Table 4 is based on descriptive statistics of ages between 21-50, including 19.2% of participants aged between 21-30. On the contrary, participants aged between 31-40 and 41-50 were involved in 36.5% and 40.4%, respectively. This highlights that many participants were middle-aged and elderly, indicating an experienced majority or professional individuals.

Table 5:

Role of Artificial Intelligence (AI) in Library's Operational Efficiency (OE)

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
AI	25.44	3.054	500
OE	28.90	3.469	500
Correlations			
		AI	**OE**
AI	**Pearson Correlation**	1	0.902**
	Sig. (2-tailed)		0.000
	N	500	500
OE	**Pearson Correlation**	0.902**	1
	Sig. (2-tailed)	0.000	
	N	500	500

Source: Authors

Table 5 tabulates the role of AI with OE along with its descriptive statistics, indicating that the respondents possess a slightly higher AI score (25.44) than OE (28.90). The standard deviations for AI and OE are 3.054 and 3.469, indicating low response variability in AI and OE. Additionally, the correlation coefficient between AI and OE is 0.902, indicating a strong correlation. Moreover, the correlation is highly significant at p-values < 0.01, indicating a strong positive correlation and a significant relationship between AI and OE.

Table 6:

Role of Artificial Intelligence (AI) in User Experience (UE)

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
AI	25.44	3.054	500
UE	29.04	3.253	500
Correlations			
		AI	**UE**
AI	**Pearson Correlation**	1	0.791**
	Sig. (2-tailed)		0.000
	N	500	500
UE	**Pearson Correlation**	0.791**	1
	Sig. (2-tailed)	0.000	
	N	500	500

Source: Authors

Table 6 shows the role of AI with UE along with its descriptive statistics, indicating that the respondents possess a slightly lower AI score (25.44) than UE (29.04). The standard deviations for AI and UE are 3.054 and 3.253, indicating low response variability in AI and UE. Additionally, the correlation coefficient between AI and UE is 0.791, indicating a strong positive correlation. Moreover, the correlation is significant at 0.791 p-values, > 0.01, indicating a strong positive correlation and a significant relationship between AI and UE.

11 THEMATIC ANALYSIS

Theme 1: Personalized Services

The qualitative analysis demonstrated positive user responses with respect to AI-based libraries regarding their perceptions and experience. The majority of the users were satisfied with the personalized services in AI-assisted libraries, enhancing their information search experience. However, few respondents stated that integrating AI in library services was an innovative and advanced technology that kept their knowledge experience with the pace of the digital era. Although, frequent users of AI-assisted libraries showed significant satisfaction due to personalized services, including suggestions and recommendations. One student mentioned,

"I've seen most of my friends come to the library to either chit-chat or bunk their classes rather than efficiently utilize library services. Since the integration of AI-based library services, it has been encouraged me to read books according to my preferences.

I feel that students and users should utilize AI-based personalized services to understand the importance of technology-led, effective learning and engage with recommended information in the library."

Another respondent mentioned,

"The most common recommended resources I have utilized are digital books, online journal databases, and library catalogs provided by AI-based libraries. These services have helped me learn and collect information even better to achieve better research goals."

Moreover, the majority of respondents expressed positive experiences and high satisfaction with personalized services offered by AI-assisted libraries. Most of them demonstrated 65% of moderate and high satisfaction regarding utilizing personalized services in AI-assisted libraries. However, the library administration also expressed significant service delivery through AI assistance. Meanwhile, a few users highlighted negative responses that may be due to being unaware of using AI-based library services.

Theme 2: Operational Efficiency and Information Accessibility

Operational efficiency and information accessibility were identified in the interview, and significant responses were received regarding AI-assisted library services. One of the library administrative staff responded,

"I recommend integrating AI in libraries because it makes my work easier in material management, allocation, and assessing users. I also realized that AI tools like Chatbots help me efficiently operate library material, especially when there is an extensive load of work."

Likewise, respondents from academic areas also expressed the importance of AI integration in library services due to vast information access. According to a student,

"I have managed to achieve good results in my course project by frequently visiting the AI-based library at my university. I was able to easily access massive knowledge and study material relevant to my course area, which assisted me in collecting new information. Therefore, I believe that an AI-based library is the main reason for achieving high grades in my course project."

The majority of respondents emphasized that AI-assisted libraries enhance their operational efficiency and information accessibility. Most of the responses were positive regarding operational efficiency and information accessibility in AI-assisted libraries;

however, approximately six respondents were unsatisfied with the AI assistance in libraries.

Theme 3: Challenges of AI-assisted Library Services

The challenges were observed through users' perceptions regarding AI-assisted library services; as a user highlighted,

"I think the most common barriers to effectively using library services are slow internet, outdated infrastructure, and a lack of training sessions and knowledge about AI-based library services."

Moreover, a student responded to a similar issue in utilizing and adopting AI in the library, stating,

"We feel that the university library lacks formal training for the librarians and the teachers concerning the programs and AI-based services launched by the library. Moreover, the lack of training has created a barrier between the teacher and the students, so the teacher cannot impart knowledge. We feel the teachers need to become more proactive to effectively utilize the services and make the students learn the same."

Additionally, the majority of the users reported being potentially unequipped to utilize AI-assisted tools effectively. Hence, these challenges and issues indicate the pertinent gap in the training for advanced technologies such as AI usage and integration. In addition, most of the respondents declared problems in employing AI-related tools to improve library services and management.

12 DISCUSSION

This research was intended to identify AI's influence on a library's operational efficiency and user experience. The findings revealed high statistical significance between AI and operational efficiency as well as user experience. However, results demonstrated a significant impact of AI on the library's operational efficiency rather than user experience, which may be an issue in utilizing AI-assisted tools. The outcomes indicated that the library services, including operational efficiency, are related to the integration of AI. Likewise, user experience also depends on the adoption of AI in libraries. Moreover, the user responses reflected the significant influence of AI on personalized services, operational efficiency, and information accessibility, which may be the reason for the high user experience. Although, library users also highlighted issues

and challenges they faced while utilizing AI-based services. This signified that the hindrance of AI applications still exists along with external issues, including lack of knowledge and training.

Meanwhile, contemporary technologies have been well-defined as effective for predicting and assessing users' preferences by employing AI-based tools in libraries, leading to user satisfaction and increased experience. AI is important in enhancing user interactions with the library by identifying their knowledge needs and preferences [15]. Various previous studies emphasized the significant role of AI in library services and management to enhance efficiency and user experience. Research by Manjunatha (2023) explained that AI-based libraries offer multiple advantages in enhancing the library's operational and management system by developing user interaction for user experience. He further highlighted that AI-assisted services in libraries include wide access to information and personalized recommendations according to users' preferences for their satisfaction [27]. The findings of current research aligned with Manjunatha's (2023) study on the significant influence of AI on user experience and operational services, advancing library services.

Similarly, the study of Ma and Xia (2022) declared that AI technologies, including blockchain, enhance resource allocation and storage with information accuracy in libraries through AI. In addition, incorporating AI in libraries boosts service qualities through data-driven processes and personalized recommendations, developing a positive user experience [21]. Simultaneously, Sa'ari *et al*. (2023) elaborated that deep learning (DL) algorithms are an AI-assisted approach that facilitates personalized search accuracy, resource suggestions, user-centric services, and information retrieval. It includes audio processing, NLP, and visual data processing, determining and predicting users' preferences to enhance their experience [16]. However, the study of Okunlaya *et al*. (2022) also demonstrated that AI-assisted services enable the development of innovative and advanced frameworks by incorporating digital tools in libraries, thus improving user experience [13]. These studies have aligned with the results of this research, focusing on highly enhanced user experience and operational efficiency in AI-assisted libraries.

Furthermore, current findings support the research of Ali *et al*. (2020) on the adequate role of AI in facilitating user-centered services by efficiently managing and operating library resources, thus resulting in a high user experience level. On the contrary, Priyadarshini (2024) accentuated that there is a challenge in employing AI technologies

due to a lack of awareness and knowledge regarding modern approaches. This issue may reduce user engagement and experience by decreasing the rate of interaction between the library and its users, thus limiting new knowledge acquisition [42]. The outcomes of this research have supported Priyadarshini's (2024) research through the identification of user perceptions regarding challenges in employing AI-based systems in libraries. In addition, there are other challenges such as a lack of innovative strategies that are available in several governmental and academic institutes, declining the rate of user experience. Pawar (2024) also demonstrated that unreliable techniques have been offered in multiple libraries and reducing the efficiency of library management and operational services [43]. Hence, these findings highlighted the need for technological awareness in order to align with emerging advancements in current society.

13 LIMITATIONS

1. The research is limited to exploring the importance of Artificial Intelligence (AI) in library operational efficiency and user experience.
2. This research is limited to explaining AI role on a specific topic, based on user library experience across different generations.
3. The current study is limited to identifying users' and staff's perceptions on integrating AI-assisted tools in the library.

14 CONCLUSION

The research revealed that the integration of AI is related to library services and management, facilitating efficient resource operations and improving user experience. Likewise, the study highlighted that the role of AI is significant in personalized recommendations, operational efficiency, and information accessibility, hence leading to a high rate of user satisfaction, engagement, and experience. The research employed mixed methods to analyze the influence of AI on the library's operational efficiency and user experience. Simultaneously, the research findings signified a strong correlation between AI and operational efficiency as well as user experience. The results also provided challenges that users faced in utilizing and operating AI-based tools due to a lack of knowledge. These need to be addressed for efficient library services and a positive

user experience. However, the research provided validity in the role of AI-assisted library services that may facilitate researchers in exploring AI applications across other areas.

15 RECOMMENDATIONS

1. Future researchers should conduct further analytical studies with large study areas across diverse cultural backgrounds.
2. Future studies should address the role of AI in diverse disciplines.
3. Stakeholders should provide AI access and operating knowledge through multiple training and awareness programs.

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Authors' Contribution

Both authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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