Innovating Academic Library Services Through the Adoption of Artificial Intelligence Technologies in Tertiary Institutions: The Nigeria Experience

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Abstract
Artificial Intelligence (AI) influence is everywhere these days, from classrooms and workplaces to even libraries. It's being used to improve library services and make sure everyone gets the support they need. However, literature has not well documented the ways academic libraries deliver their services innovatively through AI in developing countries. This paper explores AI technologies and their innovative approach to academic libraries. Also, describes the concepts, characteristics, and a brief history of AI. Moreover, the paper highlights the usage of AI in academic libraries. The study provides a few case studies in academic libraries that adopted AI. Furthermore, the paper explains the emerging issues of AI adoption. It was concluded that AI has become one of the principal driving forces and AI adoption must flourish.

Keywords: Artificial Intelligence; Academic library, Innovation; Library services, Nigeria

Introduction

The wave of technological advancement and globalisation has significantly impacted various sectors of society, including the field of librarianship. Today, technology, especially Artificial Intelligence (AI), is integral to enhancing academic library services, thereby supporting learning, research, and teaching within the educational sector. This trend is increasingly evident in advanced countries, where

technology is now considered essential for the effective and efficient functioning of libraries and the broader progression of education.

In recent decades, AI has become pivotal in transforming our world and influencing how we think, act, and make decisions. AI is defined as the ability of a digital computer, or a computer-controlled machine or software, to mimic the intellectual capabilities of intelligent beings, like humans. Scholars describe AI as the creation and development of fully conscious, intelligent, computer-based entities (Sheikh et al., 2023). Rajaraman (2014) defines AI as the science and engineering of building intelligent machines. Similarly, Zhang (2024) described AI as the application of machine learning and other techniques in research that offers opportunities for libraries to expand their services

AI aims to inspire, simplify, and manage tasks while understanding and processing human language. According to Copeland (2015), AI's primary goals include reasoning, discovery, generalisation, and natural language processing. AI has sparked considerable interest across various fields, including information science, computer science, mathematics, psychology, linguistics, and librarianship. In Library and Information Science (LIS), expert systems are the most notable application of AI.

The integration of intelligent systems into libraries began in the 1990s, utilising AI technologies to provide knowledge-based services to both library patrons and staff. Despite its complexity, AI aims to develop computer systems with human-like intelligence, significantly impacting the field of librarianship. Guliciuc et al. (2017) note that expert systems assist library professionals with basic operations, decision-making, and productivity improvement. Similarly, Massis (2018) argues that AI can operate independently of human intervention, fostering the development of intelligent libraries capable of performing tasks autonomously. Library could be described as a collection of resources organised by professionals to provide accessible information and promote learning, societal advancement, and entertainment. Libraries strive to serve all users, regardless of age, gender, or location, through various services and programs designed to meet information needs.

Modern 21st Century libraries serve as collaborative hubs that blend physical and digital resources, encouraging exploration and creation among students, teachers, and the community. The implementation of AI in libraries introduces innovation to many operations, improving subject indexing, reference services, database searching, document delivery, and material security. AI is one of the key technologies of the Fourth Industrial Revolution (4IR), alongside big data, robotics, blockchain, virtual/augmented reality, machine learning, the Internet of Things, drones, predictive maintenance, advanced analytics, robotic process automation, nanotechnology, and more. This study focuses specifically on AI's role in enhancing library services, contributing to the existing body of literature by addressing the gap in AI research within the field of librarianship in African countries.

Statement of Problem

Artificial Intelligence (AI) plays a crucial role in academic libraries, offering significant benefits such as reducing manual and repetitive tasks and minimizing errors and inconsistencies in data. However, despite the rapid expansion of AI in other fields, research connecting AI to librarianship remains limited (Amanda & Sandy, 2019). Additionally, literature indicates that only smaller universities in Nigeria have engaged with AI, making its presence in Nigerian academic libraries almost non-existent. This study is crucial for filling the gap in the literature on AI in librarianship and determining the current state of AI adoption in Nigerian academic libraries. The study aims to: trace the history of Artificial Intelligence; identify the areas within academic libraries where AI is utilised; examine the current status of AI technology adoption in Nigerian academic libraries; and identify emerging issues related to the adoption of AI by academic libraries in Nigeria.

Methods

The methodology involved conducting a comprehensive literature review to identify relevant papers on Artificial Intelligence. Search engines and databases such as SCOPUS, Science Direct, SAGE, ProQuest, DOAJ, and Google Scholar were utilized. The keywords and synonyms used included “artificial intelligence,” “deep learning,” “machine learning,” “library,” “education,” “sustainability”, “Nigeria” and “Africa” The search was refined to include only papers that (a) specifically focused on artificial intelligence and machine learning, (b) reported empirical research results, and (c) were conceptual papers significantly related to the present study. Additionally, reference lists from journals, online books, and conference proceedings were reviewed. Dissertations and theses were excluded.

Special efforts were made to ensure the selection of relevant papers from peer-reviewed, high-impact journals. References from included articles were examined to identify other potential studies missed in the initial search. This process resulted in a total of 62 papers meeting the eligibility criteria. The search was limited to a specific year range to gather current information despite AI not being a new concept. This approach ensured diverse perspectives from researchers across different countries and enriched the description of AI's innovative role in academic libraries.

History of Artificial Intelligence(AI)

Artificial Intelligence (AI) is not a novel concept; the algorithms in use today have been in existence for many decades (Stone et al., 2020). In 1950, Turing conducted the Turing Test, which aimed to discern whether a machine could mimic human behavior (Turing, 1950). The formal inception of AI occurred in late 1956 with a workshop held at the Dartmouth Summer Research Project on Artificial Intelligence (Haenlein & Kaplan, 2019; Friendly, 1974). Organized by four researchers—John McCarthy, Nathaniel Rochester, Marvin Minsky, and Claude Shannon—this two-month study involved ten participants. Their primary objective was to demonstrate that machines could precisely replicate all facets of learning and intelligence. Additionally, the workshop explored how machines could utilize language, create abstractions and concepts, solve problems typically associated with humans, and

enhance their capabilities (Kreatsoulas & Subramanian, 2019). Consequently, AI was conceptualized as the development of machines capable of exhibiting behaviors deemed intelligent when performed by humans.

The progression of AI has been steady over the decades. In the 1950s, research primarily focused on game playing, while the 1960s emphasised search algorithms and general problem-solving (Delipetrev et al., 2020; Cui & Shi, 2011). The 1970s witnessed exploration into natural language understanding and knowledge representation (Cui & Shi, 2011). The 1980s saw a period of stagnation known as the AI Winters, marked by reduced research funding (Álvarez-Machancoses & Fernández-Martínez, 2019). However, AI experienced a resurgence in the 1990s and early 2000s, achieving notable successes. The adoption of intelligent systems in libraries, replacing conventional systems, commenced in 1990.

Concept of Artificial Intelligence

Intelligence entails the capacity to grasp and apply suitable methodologies for problem-solving and goal achievement. Artificial Intelligence (AI) encompasses computer-operated robots designed to simulate human cognitive processes (Nwakunor, 2021). These robots, electronically controlled by computers, imitate human cognitive functions. AI technology facilitates machines in planning, learning, reasoning, problem-solving, mobility, and even demonstrating some level of inventiveness (Heath, 2018). It encompasses the programming and advancement of computers to execute tasks typically requiring human intellect, such as recognizing speech, interpreting visual data, translating languages, making decisions, communicating, and expressing emotions (Irizarry-Nones et al., 2017). Essentially, AI endeavors to imbue computers or machines with intelligence akin to humans to tackle intricate problems in a manner akin to human thought processes.

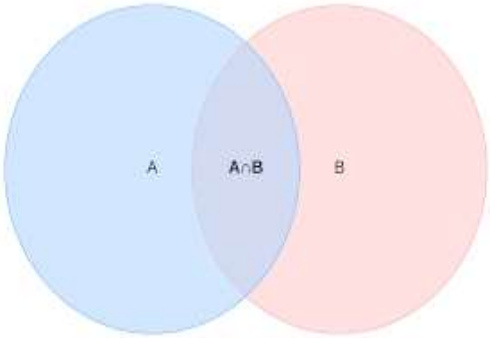
Characteristics of Artificial Intelligence

Artificial Intelligence (AI) and Robotics serve distinct purposes, although they are often confused. Many people question whether robotics is a subset of AI or if they are identical. Thus, it is important to clarify their differences.

Artificial Intelligence (AI) represents a sector within computer science dedicated to crafting computer programs capable of executing tasks traditionally associated with human intellect. AI algorithms are adept at tasks such as learning, perception, problem-solving, language comprehension, and logical deduction (Saleh et al., 2019). The field of AI is in constant evolution, with scholarly discourse often portraying AI as robots closely mirroring human characteristics.

Conversely, Robotics stands as a technological domain concerned with the design and operation of robotic systems. Robots are programmable devices capable of autonomously or semi-autonomously executing a sequence of actions. While not all robots possess artificial intelligence, there exists an overlap wherein AI and robotics intersect, resulting in the development of artificially intelligent robots.

A simple diagram can illustrate that AI is not synonymous with robots but shares certain attributes with them. The overlapping area between robotics and AI is referred to as Artificially Intelligent robots.



(Researchers self-designed, 2024)

Keys:

A- Robotics
B- Artificial Intelligences
AB- Artificial intelligence robotic

The following are characteristics of AI:

1. AI serves as a tool that enables people to rethink how we analyse data, integrate information, and utilise these insights to make better decisions (Bickley et al., 2024)
2. AI independently makes decisions, augmenting human intelligence, providing insights, and enhancing productivity.
3. AI possesses predictive and adaptive capabilities, using algorithms to identify patterns within vast amounts of data.
4. AI can perform tasks involving motion and perception.
5. AI continuously learns by using algorithms to create analytical models, learning to perform tasks through numerous rounds of trial and error(Galdorisi & Tangredi, 2024)

Application of AI in Academic Libraries' Operations

The advent of AI technology is a promising advancement for libraries, presenting a plethora of tools that can greatly benefit patron services, research endeavors, and educational support. AI holds considerable potential in various aspects of library and information center functions, encompassing tasks like descriptive cataloguing, technical services, collection development, subject indexing, reference assistance, database querying, and document retrieval. Integration of AI into library operations has the potential to elevate user satisfaction levels. Several research studies (Wheatley & Hervieux, 2019; Pinfield et al., 2017) have shed light on AI applications within library contexts, including the implementation of chatbots, document categorization, personalised services, text and data mining (TDM), intelligent learning platforms, and user exploration tools. The adoption of AI stands to enhance performance across diverse operational domains.

A. Application of Expert System jn Library

Intelligent library systems harness AI technologies to furnish knowledge-based services to library users and personnel alike. AI represents a multifaceted and expansive domain of inquiry, aspiring to develop computer systems capable of matching human intelligence, a prospect that carries profound implications for the field of librarianship (Asemi & Asemi, 2018). There have been endeavors to scrutinize research and developmental endeavors pertinent to librarianship, drawing insights from prominent frameworks of human intelligence. Through this examination, ten factors have been pinpointed as particularly pertinent to Expert Systems (ES), encompassing aspects like acquisition, automation, comprehension, memory management, metacognition, numerical prowess, reasoning, social adeptness, verbal acumen, and visual perception, all of which bear relevance to library and information science (Asemi et al., 2018).

Application of Expert System in Acquisition: The primary function entails obtaining pertinent library materials for inclusion in the library. This can be accomplished by both librarians and library users through the development of electronic collections. Various systems have been integrated for this purpose, such as the Monograph Selection Advisor, representing an initial endeavor in applying this emerging technology to build library collections. Additionally, the process emulates the item-by-item decision-making typically conducted by subject bibliographers when selecting monographs, utilising the expert system. However, it is imperative for the knowledge base to be sufficiently extensive and for the interface to be user-friendly to ensure that the library can effectively retrieve the desired information from the system.

B. Application of Expert Systems in Reference Services

The key functions within the reference section can be facilitated through the implementation of AI expert systems in reference services. According to Asemi et al. (2018) and Gujral et al. (2019), AI can be applied across various areas of library services as outlined below:

1. Online Reference Assistance (ORA): This essential service provided by reference librarians can leverage various technologies, including videotext-like databases, computer-assisted instruction modules, and knowledge-based systems. ORA encompasses directional transactions, such as inquiries regarding library locations, services, and policies.
2. Information Pointer: Reference librarians can effectively utilise computer systems to assist patrons in locating reference sources. The expert system guides users to relevant reference sources, functioning as a computer-assisted reference program rather than a Knowledge-Based System.
3. Research: Expert systems can be employed by reference librarians to teach students referencing skills or serve as a computerised aid for practicing reference librarians and information specialists.
4. PLEXUS: This tool facilitates information referral services for library users, particularly in public libraries. It incorporates knowledge about

the reference process, specific subject areas, reference sources, and library users.

5. ANSWERMAN: A knowledge-based system designed to assist users with reference questions related to agriculture topics. Utilising a series of menus, it helps narrow down the subject of questions and the type of tool needed. It can function either as a consultation system or as a front end to external databases and CD-ROM reference tools.
6. Chatbots: These automated systems can handle directional questions on a library website, provide alerts for due books, direct users to relevant library resources, or address simple information requests. Chatbots are already being deployed on various websites to address patron questions, provide directional guidance, and direct patrons to relevant resources. Introducing conversational systems in libraries and museums can enhance patron query resolution and improve accessibility.

C. Application of Expert System (ES) in Classification

A fundamental task within the technical services division of academic libraries involves classification and cataloging, which plays a crucial role in organising knowledge within libraries and information centers. The implementation of an Expert System proves particularly beneficial, especially in the realm of classification. Moreover, Expert Systems can also find application in the following domains:

1) Coal SORT: This tool functions as both a search and indexing tool, incorporating a frame-based semantic network and the necessary software to enable users to navigate through and highlight portions of the conceptual structure. The expert knowledge within the system primarily resides in the semantic network.
2) Environmental Pollution Expert (EP-X): EP-X shares similarities with Coal SORT in that both focus on improving the interface using a Knowledge-Based approach. EP-X's knowledge base consists of a hierarchical frame-based semantic network of concepts and a set of template patterns known as conceptual information.
3) BIOSIS: This tool serves as an aid for indexers, utilising its knowledge base. BIOSIS leverages the information contained in the titles of biological documents to assign categories, mimicking the process conducted by human indexers. The indexing languages provided are structured representations of information, offering significant advantages for AI applications.

D. Application of Expert System in Indexing: Expert systems contribute substantially to the indexing process of periodicals. Indexing an article in a periodical entails identifying concepts, translating them into verbal descriptions, and choosing controlled vocabulary terms that precisely convey these concepts. Automating the intellectual facets of indexing seeks to improve the consistency and caliber of indexing. Leveraging information furnished by indexers, these systems can autonomously identify suitable preferred terms and allocate pertinent

subdivisions. The system is capable of making suggestions and taking appropriate actions based on inference. An illustrative example is 'Med Index', which exemplifies an indexing system widely utilised in libraries for indexing activities.

E. Application of Pattern Recognition in Library Activities

In the contemporary age of the Internet and multimedia computing, along with the emergence of new classes of information systems applications, office workers are experiencing significant transformations. The proliferation of new applications such as digital libraries, multimedia systems, geographic information systems, collaborative computing, and electronic commerce has opened up vast opportunities for information researchers and practitioners alike.

F. Applications of Robotics in Academic Library Activities

The integration of electronic and print-based resources and services has posed significant spatial limitations for many libraries, particularly academic research libraries (Okpokwasilli, 2019). To address this issue, the Comprehensive Access to Printed Material (CAPM) initiative endeavors to develop a robotic scanning system that operates on-demand and in batches, enabling real-time browsing of printed material through a web interface. Users will engage with the CAPM system, prompting it to deploy a robot for retrieving the requested item. Subsequently, another robotic system will open the item and autonomously flip through its pages. Utilising existing scanners, optical character recognition (OCR) software, and indexing tools from the Digital Knowledge Centre, the CAPM system will not only facilitate the browsing of textual images but also enable searching and analyzing of full-text content derived from these images. Now, let's explore a few academic libraries that have implemented AI in their library operations.

Case Studies of AI from Academic Libraries in Nigeria

Table1: Nigerian University Libraries with Artificial Intelligence (AI) and Robotics Adoption

S/No	Name of Organisation	AI Functions
1	Lead City University Library	The university implemented an Artificial Intelligence powered book recommendation system to assist users with a selection of books to read. This can be achieved by using machine learning algorithms to analyze users' reading preferences and suggest books that match their interests.
2	Covenant University Library	This university implemented an AI-powered chatbot to provide information on library services and resources to its users. The chatbot, known as CULibrarian, serves as an interactive tool for addressing users' queries. It offers guidance on library policies and procedures, as well as aids in research inquiries.

3	University of Lagos, Nigeria	AI has been employed to enhance delivery operations through the introduction of robots.AI usage tagged Robo Scholar AI provides the data of people coming to the library every day, looking at the peak time that they come in, and the peak hour, they leave.
4	University of Nigeria, Nsukka	University implemented an AI-powered chatbot to provide library services to its users. The chatbot; called "Ask Ada," can answer users' questions, provide information on library resources, and assist with research inquiries.
5	Baze University, Abuja	University implemented a robot to assist users with locating books and other materials in the library. The robot can guide users to the location of specific books, and it can also provide information on the library's services and resources.

(**Source:** Authors' generated, 2024)

Table 1 provides a brief discussion of activities of academic libraries that have commenced the adoption of Artificial Intelligence and Robotics for their various library operations. From Table 1, it is highly discouraging that only five (5) universities out of 170 functional universities that were approved at National Universities Commission (NUC, 2023) adopted AI. What might be responsible for low adoption of AI in academic libraires in Nigeria could be traced to emerging isuues confronting academic libraries.

Emerging Issues in Artificial Intelligence's adoption by academic libraries in Nigeria

Artificial Intelligence (AI) refers to a tool or system capable of executing a particular intelligent task, also known as artificial narrow intelligence (ANI), and its presence is steadily expanding across Africa. However, despite the significant benefits AI systems offer to the continent, several barriers hinder their adoption and utilisation. The challenges confronting the adoption and use of AI include:

1. Inadequate Expertise: A significant barrier to the adoption of AI in libraries is the lack of competency among stakeholders. Mastering AI skills is challenging, leading to a shortage of expertise to meet the demand. This scarcity of AI proficiency is particularly pronounced in developing markets like Africa (Ajadi, 2020).
2. Digital Literacy Deficiency: Another major obstacle to AI implementation in Africa is the lack of digital literacy skills. Sub-Saharan Africa lags behind other regions in terms of digital skills adoption, hindering the development, implementation, and utilization of AI applications (Madden & Kanos, 2021). Stakeholders in the education sector recognize the necessity for enhancing skills during the

4th industrial revolution to effectively leverage AI technologies (Ade-Ibijola & Okonkwo, 2023; Oke & Fernandes, 2020).

3. Poor Internet Connectivity: Effective utilization of AI in libraries relies heavily on robust internet connectivity. Inadequate infrastructure and investment in internet infrastructure across Africa, such as fibre-optic cables and cell towers, contribute to poor internet penetration rates (ITU, 2021).
4. Limited Data Access: Insufficient data accessible to African researchers poses a significant challenge to the adoption of AI in Africa. Machine learning algorithms require large datasets for training, and the lack of representative data hampers algorithm effectiveness (ITU, 2021).
5. Funding Constraints: The adoption and use of AI in libraries require substantial financial investment. Inadequate funds may prevent libraries from acquiring the latest ICT gadgets necessary for effective AI utilisation (Osagie & Oladokun, 2024; Udo-Okon & Akpan, 2024)
6. Fear of Job Displacement: Despite the numerous benefits of AI, stakeholders often fear job displacement due to AI applications. Concerns about automation disrupting traditional work processes hinder widespread acceptance of AI (Mzmkandaba, 2019; Ade-Ibijola & Okonkwo, 2023). This might be due to limited knowledge of AI by stakeholders that lead to resistance to change as result of negative perception towards adoption of AI technologies.
7. High Cost of AI Technologies: The high cost of ICT equipment, coupled with a lack of digital infrastructure, discourages AI adoption and use in Africa.
8. Political Interference: Dirty politics may result in policies that discourage experts from showcasing their skills, leading to brain drain within the AI sector.
9. Ethical Issues: Ethical considerations pose a challenge to AI adoption in Africa, with initiatives struggling to address ethical and legal concerns arising from AI technology. As reitersted by Okoje and Awoyemi (2024) that AI intergration in the academic library context may be subject to potential ethical breaches.
10. Limited involvement of stakeholders in AI Technologies: The low participation in AI technologies among stakeholders is one of the challenges facing adoption and use of AI (Okoje & Awoyemi, 2024)
11. Lack of Relevant Government Policies: Many African countries lack comprehensive AI legislation and regulatory frameworks, primarily due to policymakers' limited expertise in AI and related emerging technologies. Also, the absence of AI legislation proposed by African governments highlights the need for policymakers with technology expertise and greater involvement of highly-experienced professionals in developing AI legislation (Daoud & ZereGoitom, 2022).

Conclusion

Artificial Intelligence (AI) has become a broad category encompassing various digital tools that are reshaping the landscape of libraries. While the adoption and utilisation of AI are rapidly increasing worldwide, academic libraries have been slow to adopt AI technologies, with the current level of adoption being minimal. Moreover, there is a dearth of research on AI in librarianship, particularly in Africa and Nigeria, creating a significant gap in the literature that requires attention.

AI tools such as chatbots, document classification, personalized services, text and data mining (TDM), intelligent education, and user discovery offer promising avenues for research, access provision, and educational development in libraries. These tools have the potential to enhance education by providing deep intelligence offerings and fostering educational growth. Additionally, recent advancements in AI have enabled libraries to provide AI education to stakeholders at various levels.

Furthermore, AI applications in libraries can facilitate the creation of community spaces where patrons can interact with information in a safe and private environment. AI can also assist library users with learning difficulties and support librarians and educators through personalized learning experiences. As AI becomes increasingly integrated into library operations, there is an opportunity for the profession to embrace AI and embark on a journey of coexistence with this transformative technology.

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