Trends in Information Management (TRIM)
ISSN: 0973-4163
13(1), pp. 30-44

Smart Technologies for Smart Library Services Delivery in Academic Libraries in Developing Countries: Challenges and Prospects

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Abstract
Smart technologies form the foundation of smart library services in advanced countries and are gradually being adopted in academic libraries of developing nations. This paper, based on a systematic literature review, identifies and recommends suitable smart technologies such as robots, drones, big data, mobile apps, and blockchain for enhancing library operations and improving user services. Despite their potential, challenges such as power outages, poor funding, and weak internet penetration hinder effective implementation, particularly in Africa. Addressing these barriers through adequate funding and efficient management will enable academic libraries to integrate smart technologies and deliver demand-driven, techno-centric services to better meet users' information needs.
Keywords: *Smart Library Services, Smart Technologies, Academic Libraries, Mobile Apps, Drones, Big Data, Block Chain Technology and Robots.*

Introduction

In the developed countries, academic libraries have integrated modern technologies in their libraries in order to meet up with ever increasing and changing demands of library users. This information quest by users is necessitated by evolving technologies which gave rise to smart services, and smart library services are founded by the sophistication emanating from the information seeking behaviours and needs of library users (Orji & Anyira, 2021). Fundamentally, libraries in developing countries are still offering conventional services in acquisition, organisation (cataloguing and classification), serials control and other public services delivery (circulation and reference services). Today, smart library services have influenced the operations and services offered in libraries. Nahak and Padhi (2019) defined smart library as services provided to users via smart technologies for accessing information and these services are provided through mobile and wireless access platforms, Radio Frequency Identification (RFiD), remote assistance, artificial intelligence, machine translations, voice and image recognition, semantic web, Internet of a Thing (IoT), etc. The authors further exposed that smart library services must be user-centred and friendly too; and recommended that it should offer a wide range of web based and digital library services to users; ensuring the provision of access to online learning information resources for library users.

Conversely, smart library services cannot be performed without equipping the academic libraries with basic ICT tools which will upgrade them to smart

libraries. In this study, smart libraries are libraries without physical shelves and printed books and are referred to as digital archives which are linked via computers with Radio Frequency Identification Devices, International Management Systems (ILMS), Standard Digital Software (DSpace/E-prints), Content Management Software, Web-OPAC, federated search tools and discovery tools (Nahak & Padhi, 2019; Saloi, 2021). Therefore, smart libraries connote libraries that utilize smart technologies such as mobile apps, big data, drones, robots and even AI tools for rendering smart library services. Similarly, Saloi (2021) revealed that mobile apps are prerequisites for utilization of drones services for document delivery to library patrons. This shows the interconnectivity that exists between smart libraries and smart technologies in academic libraries.

Academic libraries being the hub of intellectual activities in the academic institutions are required to exploit smart technologies to offer smart library services delivery to users. Odeyemi (2019) exposed the smart technological trends for smart library services in libraries to include, humanoid robots, gesture recognition, mobile app, immersive reality, augmented reality, virtual reality, sensory immersion, and gamifications. In the study of technological trends in libraries: transforming libraries, smart users, smart services and smart resources, Chingath (2020) exposed that Mobile Apps, Robotics, Blockchain, Big Data and Drones are the trendy smart technologies which academic libraries can leverage for information service delivery. Smart technologies streamline library operations and services by providing plethora of technologies for smart library services delivery in a global and ICT driven world irrespective of hindrances and perplexing situations which are eminent.

Libraries in developing countries encounter challenges of integration of technological devices which stretches to lack of infrastructural development, limited internet access, lack of IT skilled personnel, erratic power supply, lack of adequate infrastructure, poor funding, and budgeting of academic libraries (Okoye, 2024; Yusuf et al., 2022). For example, in a survey on challenges of Artificial Intelligence (AI) in libraries across Africa, Abba (2023) identified financial constraints, lack of skilled personnel, training of librarians, low awareness level of this technological device in library, fear of loss of job, inadequate infrastructure, poor funding of libraries, cost of training librarians on the use of AI. All these resulted in lack of integration of smart technologies for smart library services in academic libraries in developing countries. Therefore, these challenges seem to be bordering on academic libraries as information centres where smart services are required to be offered.

Hence, in developing countries, library services are expected to be offered through smart technologies for library users. This paper is therefore; set to explore different smart technologies and how they can be applied in the

library for enhanced operations and services in the academic libraries and for the benefit of the library and users in developing countries such as Africa. The Problem is the advances in technology which is dragging libraries in developing countries. They must keep pace with the global trends in services in modern libraries so as to retain the perceptions and expectations of users in academic libraries. Libraries that are unable to use smart technologies to provide smart services to their clients are to be by-passed and unable to satisfy the yearning interests of their patrons.

The purpose of the Study

This study seeks to explore the smart technologies for smart library services delivery in academic libraries in developing countries. The specific objectives are to:

1. Identify the smart technologies for smart library services delivery in academic libraries.
2. Explore the application of smart technologies to library services in academic libraries.
3. Identify the challenges of smart technologies for smart library services in developing countries.
4. Recommend ways of overcoming the identified challenges in the academic libraries of the developing countries.

Smart technologies for smart library services delivery in academic libraries

The incorporation of smart technologies such as Robots, Big Data, Drones, Block chain Technology and Mobile Applications into the library system have great impact towards libraries and their services. Robot is one of the smart technologies which can be deployed in the academic libraries in order to render smart library services to users. Moraves (2024) defines a robot as an operated automatic machine which has taken over human efforts but does not necessarily appear or take after human beings in outlooks or execute duties in the manner humans does. It is also defined as a machine that is automated and can perform defined works with speed and precision with little or without any intervention of humans (TechTarget Contributor, 2023). Therefore, in this study, robots are automated machines that carry out functions as humans but are notable for their fastness and accuracy. Another smart technology for smart library services is the big data.

Big data has to do with large data sets which are known for its high volume, velocity, variety, value and veracity in terms of generation of data. They are data sets that cannot be managed with the use of computer hard disk drives and as a result need to be managed with some special software's. In addition to the use of software's to manage big data, data analytics is also vital to the generation of voluminous data sets. According to Tech America Foundation

Federal Big Data Commission as cited in Okafor et al (2018), big data refers to large volumes of data known for its high velocity, it compiles variable data that requires advanced techniques and technologies for capturing, storing, distributing, managing and analysing information. The volume of data of big data are usually in terabytes and petabytes, they are above megabytes and as such gave rise to the need of using data analysis technologies in mining big data (Mc Ardle, as cited in Adetayo et al., 2021). Another smart technology for smart library services for improved library services is known as a drone.

Drone is a remotely controlled aircraft known as Unmanned Aerial Vehicle (UAV) used for surveillance, spy, video coverage, agricultural purpose, delivery of goods and services and has been integrated into the library for an enhanced service delivery. It is remotely controlled from a distance by a human operator. Mendhe (2021) defines a drone as remotely controlled small flying equipment and a trendsetter in science while Saloi (2021) and Wang et al. (2023) explained that drones are Unmanned Aerial Vehicles with limited flight and duration range which can be used for parcel delivery. Therefore, drones are smart technologies that flies up the sky and remote controlled in order to deliver specific assignments programmed for it. Smart technologies do not end with drones but encompass other technologies such as block chain technology.

Block chain technology is a decentralised and distributed ledger technology that maintains recorded information which a community shares; block chain technology is like a database with digital records of transactions (Suman & Patel, 2021). Block chain technology makes information recorded in the system to be more secured by not allowing hacking, manipulating or changing of the information. Block chain technology permits duplication and distribution of information or transactions in all the network of participating computers as a distributed ledger (Kitthu, 2025). Apart from block chain technology, mobile app is a further useful smart technology for smart library services in academic libraries.

Mobile app is software designed specifically for operation using mobile devices like Smartphone's, tablets and Personal Digital Assistant (PDA) in order to perform a specific task for users. Jia et al (2020) defined mobile app as a software application which runs on a tablet or Smartphone's.

Application of smart technologies for smart library services in academic libraries

There is a paradigm shift from conventional library services to smart library services which paved way for adoption and integration of smart technological devices in libraries. This has led to significant changes in library operations and services as discussed in this study.

Robots Applications for Smart Library Services in Academic Libraries

Robots are given credits because of the fact that they perform certain functions even better than humans (TechTarget Contributor, 2023), and some of these functions include: repetitive tasks in corporate organizations; delivery of online orders; monitoring of services; processing and delivery of reports for security purposes. In the academic library, Robots can perform classification, sorting and filing library materials; delivery of some library materials such as magazines, brochures, newspapers and pamphlets; replacing books on the shelves while talking Robots can welcome library users, give them directions and guides, respond to Frequently Asked Questions (FAQs) and inventory purpose (Chingath, 2020; Tay, as cited in Oniovogha et al., 2023).

Big Data Applications for Smart Library Services in Academic Libraries

Big data sources are found in the social media such as Linked in, WhatsApp, Google+ and Instagram are relevant to generation of big data in libraries. Three categories of big data sources as identified by Adetayo et al. (2021) are data streams, library social media and public domains. Data streams according to the literature concern data that are created and processed via computers, mobile-mediated data like sensor data, log files, position tracking and processor generated data while public domain refers to data that are available on the internet for public consumption. Big Data software's can be used to analyse library big data found in social media sites, data streams and public domain in order to generate data and solve problems in the academic libraries. Several things necessitated the use of big data in the library. Such things as digitization of library resources (Wang et al., 2016), libraries institutional repositories and social media use in libraries such as Twitter, Facebook, Blogs and Text messages (Okafor et al., 2018). Big data software and analysis add values to the information services offered in academic libraries by identifying and analysing useful data which contribute significantly to reaching out to the information needs of researchers in the libraries and facilitating of service delivery in libraries (Wang, 2016; Adetayo et al., 2021).

Drones Applications for Smart Library Services in Academic Libraries

Drone has the capacity of improving the operations of libraries by making them to function optimally. Jaeger and Kettnich (2023) and Adetayo et al. (2021) exposed the fact that in libraries, drones can be used to survey very big collections of manuscripts and rare books in order to check their conditions including identification of books in the stacks that require mending and repairing. Santra et al. (2021) maintained that drones can be helpful in the reprography services, data collection, remote viewing security; cleaning and dusting especially with arm robotic drones.

Furthermore, Kohli et al. (2021), Liang et al. (2023) and Rawat et al (2023)

affirmed that with drones, real-time data can be provided in libraries in terms of inventory levels, library usage and other important metrics in order to improve the efficiency of libraries. Other uses of drones in library operations as they noted are theft and vandalism detection, scanning of library collections, security and surveillance to ensure safety of library environment. Drones are used for referral services and document delivery in the library and for an enhanced work output (Rawat et. al, 2023; Saloi, 2021). Mendhe (2021) further declared that drones can be used to create content for the library and store data in order to render smart library services to users.

Block Chain Technology Applications for Smart Library Services in Academic Libraries

Block chain technology has revolutionized various sectors, offering unprecedented levels of transparency, security, and efficiency. Block chain has the potential of improving library services and functions through its interoperability, thereby making resources more accessible and trustworthy for users; it is essential for enhancing the rectitude and security of library data through its tamper-evident and immutable record-keeping capabilities (Halpin, 2016; Smith, 2019). Block chain can enhance various library functions, including cataloguing, authentication, digital rights management, and scholarly communication. Sharma & Batth (2020) averred that block chain technology can be used for gathering, sharing and preserving authentic and valid information in libraries and it is devoid of many technological hurdles. Similarly, Verma (2021) argued that block chain is needed in keeping library records such as acquisition in terms of stock verification, circulation on the area of books movements, fees and fines collections. Each transaction within a library system, such as cataloguing a new item or lending a book, is recorded on the block chain, creating a transparent and auditable trail of activities (Attfield & Ben, 2017). Traditional library cataloguing systems typically rely on centralized databases managed by library staff (Smith, 2019). However, block chain technology introduces a paradigm shift by enabling decentralized cataloguing, where multiple stakeholders can contribute and verify metadata records collaboratively (Daniel et al., 2018). Therefore, Block chain technology promotes decentralized cataloguing and metadata management.

Block chain technology also offers identity solutions which are decentralized in order to allow users to control their personal information while providing secure authentication mechanisms (Daniel et al., 2018). Identity management is crucial for verifying the credentials of library users and ensuring secure access to digital resources (Castiglione et al., 2019). The emphasis is that block chain technology improves authentication and identity management. Block chain technology holds the potential to transform scholarly communication by enabling transparent and immutable

records of academic publications, peer reviews, and citations (Monaco et al., 2018). Block chain-based publishing platforms can facilitate open access publishing, eliminate predatory practices, and ensure attribution and recognition for authors and reviewers (Wang et al., 2020). These foster greater collaboration, accountability, and trust within the scholarly community while reducing barriers of access to knowledge (Monaco et. al., 2018). Therefore, block chain technology facilitates scholarly communication and peer review practices of scholars and researchers.

Application of Mobile Apps for Smart Library Services in Academic Libraries

Mobile Applications are used in libraries in form of WhatsApp, YouTube, and E-mail, Quick Response code (QR) and Mobile Public Access for the provision of smart library services to library users. Singh and Madhusudhan (2023) identified the aforementioned as mobile apps which can be utilised for this purpose including smart library services such as Short Message/Messaging Service (SMS), Mobile Online Public Access Catalogue (MOPAC), Mobile Databases, Really Simple Syndication (RSS) and Mobile Websites. According to Gaffer and Kumar (2019) mobile app is an emerging technology used by academic libraries in disseminating information and providing users access to e-thesis, e- journals, directories, and reference services. This application saves time and it is easily accessed remotely.

Mobile Application is a proactive method of connecting users to libraries. With the use of mobile app in libraries, users can access library database, obtain needed information through Ask a Librarian without a physical visit to the library; Ask a Librarian can access a wide range of information resources on the library website (Mishra et al., 2017). Ali and Asi (2019) agreed that mobile application is used to improve library services such as Ask a Librarian, mobile library services, databases and e-mail notifications. In support, Kesselman (2022) disclosed that mobile technology takes hold of library services and productivity. Rajasekhar and Sasikala (2018) opined that an application such as You Tube is used to support teaching and learning. It has created easier connection between libraries and their patrons, and enabled increased access to information resources. However, apps such as Lib Anywhere is used to access library catalogue while Access my Library is a free app which allows users to access information resources available on their university database such as Directory of Open Access Book (DOAB) and Directory of Open Access Journal (DOAJ).

Challenges of adoption of smart technologies for smart library services in academic libraries in the developing countries

A study carried out by Sambo and Tinuoye (2023) and Shahzad et al. (2024) revealed the challenges limiting adoption of robots in the libraries as lack of

training opportunities, lack of IT capabilities, lack of financial resources, and shortage of skilled personnel, erratic power supply, lack of maintenance culture/high cost of maintenance, fear of job loss, lack of operational expertise, technical difficulties, lack of infrastructure and inadequate ICT facilities. Other identified challenges include: shortage of competent manpower, non-ICT- LIS curriculum, budget cut and inadequate planning, non-challan attitude of librarians towards the adoption of these technologies, high cost of acquiring the device, economic factors, poor funding, lack of skilled IT personnel (Dei, 2020; Echedom & Okunghae, 2021; Hussain, 2022; Olubiyo & Awoyemi, 2021; Omobolanle et al., 2024). All these are factors mitigating the adoption of robots, big data, drones, block chain technology and mobile app in academic libraries in the developing countries generally.

Precisely, lack of digital awareness is hampering the big data integration in libraries across Africa and developing countries at large; lack of required ICT expertise, complexity of technological interface, budget cut; lack of organizational polices, infrastructural gaps, and cost of integrating these technologies are the impeding on implementation of big data in academic libraries of developing countries (Adeleye et al., 2024; Alalawneh and Alkhatib, 2020; Oladokun & Aboyade, 2023; Saibakumo, 2021). The study of Saloi (2021) on drones in libraries for document delivery, identified limitations of use of drones in the libraries which include delays in documents delivery due to unfavourable weather issues, the regulations that bans the use of drones in some countries, risk of being stolen or hacked, and limited carriage capacity and flying range. Mustapha and Yusuf (2023) and Nath (2018) encapsulated the challenges of drone in libraries as possible drone malfunction on the course of delivery on the air, delays occasioned by strong winds or rain, legal issues which might prohibit deliveries by drones at some hours such as night and security of items in the drones targeted for delivery, merging skill gaps, and operational inefficiencies.

Furthermore, the study of Owraigbo & Onah (2023) revealed that privacy issues, and the costs of block chain infrastructure are the specific challenges faced by libraries towards the integration of block chain technology in libraries for smart library services**.** All these highlighted factors hinder the adoption and integration of smart technologies for smart library services in academic libraries in the developing countries.

Conclusion

Smart technologies for smart library services enhance and streamline information service delivery in academic libraries. The users of academic libraries are knowledge and technology driven and as such require smart library services. Such innovations in technologies otherwise referred to as smart library services as highlighted in this paper include Robots, Big data,

Drones, Block chain Technology, and Mobile Apps. These technologies provide newer dimensions to service delivery in academic libraries. Moreover, the applications of each identified smart technology were highlighted and discussed including the challenges of adoption of the smart technologies in the developing countries.

Recommendations

The paper recommended the following after highlighting different smart technologies for smart library services delivery, their applications and challenges in academic libraries in the developing countries:

1. Academic libraries need to integrate newer technologies in performing library operations and services in order to meet the information needs of their users who are digitally and technologically driven.
2. In order to combat lack of funds in academic libraries, libraries should seek for alternative funding through Non- Governmental Organizations, Internally Generated Revenues (IGR's), philanthropists and advocacy programmes in order to augment their poor budgets.
3. Trainings are required through seminars, conferences, workshops, hiring of resource persons outside the library who possess the knowledge and ensure that these resource persons' train others on use of emerging technologies required to make academic library services smarter.
4. Alternative power supply such as inverters are required, energy from Compressed Natural Gas, Diesel and the likes to ensure stable power supply.
5. Internet bandwidth should be enhanced for better optimization of the internet. It can be diversified by providing additional network from routers, starlinks etc.
6. Academic libraries should adopt the use of Robots such as humanoids to carry out boring and repetitive tasks and for answering reference queries, library tours and document delivery in general.
7. There is need for academic libraries to adopt Blockchain technology in order to share authoritative information among themselves and for transparency and security of their information from hackers and manipulators.
8. Library resources in academic libraries need to be safeguarded by surveillance which drones can be used to achieve in order to avoid theft and mutilation of library materials in addition to discovering torn library rare materials in vast collections that require reinforcements.
9. There is need for academic libraries to modify their traditional library services and make them available to users through Mobile apps as they help library user to access e-resources, directories and reference services.

10. Academic libraries should make their information services smarter by adopting big data analytical tools in order to identify and analyse useful data which will in turn facilitate service delivery to users in addition to advance compilation of various data in the library.

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