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Research Article

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ICT application in Nigerian libraries: the need to look into the direction of 4IR technologies following the perspective of diffusion of innovation theory

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ABSTRACT

Introduction: Libraries in Nigeria have been adopting ICT; however, they have not been fully integrating the 4IR technologies. Objective: This study examined the development process as a case of the application of ICT in Nigerian libraries and the need to look in the direction of 4IR technologies. 6 libraries were drawn from the 6 geopolitical zones in Nigeria. Methodology: An open-ended survey posted to the respondents through the mail was used for data collection. Results: The findings show that ICTs such as computer systems, electronic mail, MARC, OPAC, reprographic technology, printing technology (printers), storage devices (Floppy Disk, CD), microfilms, facsimile machines, and scanning machines have been used in libraries since the beginning of 1960s. The findings identified the reasons for libraries to look in the direction of 4IR such as being a game-changer for the industries at large, being the trend and order of the day for any organization that wants to grow fast and serve their users better, the opportunity of taking libraries to the next level where librarians can work side by side with robots, cloud computing, AI, and other technologies, makerspaces, and internet of things IoTs. Challenges identified libraries in Nigeria can face when looking in the direction of 4IR technologies include funding, inadequate personnel/experts, limited power supply, and a limited budget for procuring technology and training personnel who will be in charge of technology maintenance. Conclusion: The study concludes with the recommendation that Nigerian libraries should be adequately funded to procure 4IR technologies, and should consider recruiting librarians with relevant requisite skills to work with the technology.

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Academic libraries. Librarian. ICT application. 4IR technologies. Nigeria.

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RESUMO

Introdução: As bibliotecas na Nigéria têm adotado as TIC; no entanto, não têm integrado totalmente as tecnologias 4IR. Objetivo: Este estudo examinou o processo de desenvolvimento como um caso da aplicação das TIC nas bibliotecas nigerianas e a necessidade de olhar na direção das tecnologias 4IR. Foram selecionadas 6 (seis) bibliotecas das 6 (seis) zonas geopolíticas da Nigéria. Metodologia: Para a coleta de dados, foi utilizada uma pesquisa aberta enviada aos entrevistados pelo correio. Resultados: Os resultados mostram que as TIC, como os sistemas de

computador, o correio eletrônico, o MARC, o OPAC, a tecnologia reprográfica, a tecnologia de impressão (impressoras), os dispositivos de armazenamento (disquete, CD), os microfilmes, as máquinas de fax e as máquinas de digitalização têm sido utilizadas nas bibliotecas desde o início da década de 1960. As conclusões identificaram as razões para as bibliotecas olharem na direção da 4IR, tais como o facto de ser um fator de mudança para as indústrias em geral, de ser a tendência e a ordem do dia para qualquer organização que queira crescer rapidamente e servir melhor os seus utilizadores, a oportunidade de levar as bibliotecas para o nível seguinte, onde os bibliotecários podem trabalhar lado a lado com robôs, computação em nuvem, IA e outras tecnologias, espaços de criação e Internet das coisas IoT. Os desafios que as bibliotecas na Nigéria podem enfrentar quando olham na direção das tecnologias 4IR incluem o financiamento, pessoal/especialistas inadequados, fornecimento de energia limitado e um orçamento limitado para a aquisição de tecnologia e formação do pessoal que será responsável pela manutenção da tecnologia.

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Bibliotecas universitárias. Bibliotecário. Aplicação de TIC. Tecnologias 4IR. Nigéria.

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1. INTRODUCTION

The impact of information and communication technology (ICT) on all aspects of human life has been enormous. It has resulted in significant and drastic changes in the way modern libraries operate and are managed. It has had a significant impact on library operations, information resources, services, and staff skill needs, as well as user expectations. Academic libraries throughout the world have seen a substantial transformation in the previous two decades, transitioning from a solely manual service delivery system to a more dynamic technology-driven system (Hanelt *et al*., 2021). Only in the new millennium has this transition become more visible in Nigeria. The university library system has been engulfed by the technology-driven environment, which is propelling it to new heights in knowledge resource acquisition, management, and communication. Even the terminology of librarianship is evolving, according to Siddiqua, Ansari, and Ansari (2021) "dissemination" is being replaced by "communication," "repository" by "database," "literature" by "knowledge," "search" by "navigation," and so on. This represents the current approach to knowledge packaging as well as the tools used to manage it. Twenty years ago, no one could have foreseen how prevalent knowledge would become.

Ahmat and Hanipah (2018) opined that libraries have gone through three stages of ICT development over the last half-century. The first was the introduction of automation systems in libraries, which resulted in a decrease in the use of paper. It began in the late 1960s with the development of Machine-Readable Cataloguing (MARC), which was widely discussed among professional librarians until the 1990s when academic libraries began to use the Online Public Access Catalog (OPAC), audio-visual media systems, and web-based indexes to replace their printed resources. Second, electronic libraries have dominated since the emergence of CD-ROMs, full-text databases, the Internet, and the World Wide Web in the early 1990s. Some of the established technology from the 1960s was disturbed at this time. For example, analogue audio-visual records recorded on cassette tapes have begun to be replaced, and media content became more easily accessible and less expensive via the Internet. Third, the rapid adoption of new technologies allowed for the completion of more difficult jobs. The new tools were intended to provide strong functionality for processing data, text, sound, and photographs, as well as the ability to simply send data to remote collaborators. However, all of this development has been altered by the emergence of the Fourth industrial revolution (4IR).

Without a doubt, we have entered the 4IR, which is marked by current information technology (IT). This technology includes the Internet of Things (IoTs), big data, blockchain, robotics, artificial intelligence, cloud computing, makerspaces, machine learning, and virtual and augmented reality. Dube (2022) noted that academic libraries all around the world are embracing the 4IR technologies by incorporating them into their operations and services. In this 4IR era, libraries are transforming more than just gorgeous bookshelves. As academic libraries provide a growing array of digital library services and resources, they also have large print collections. It's time-consuming to keep track of huge volumes in libraries, but robotics and artificial intelligence can help. It is no longer news that 4IR technologies are already in use in certain libraries around the world, in both developed and developing countries. In the twenty-first century, technology has grown at an exponential rate, and we have now arrived at a point when "the promises of science fiction are swiftly becoming a workaday reality." (McAfee; Brynjolfsson, 2016, p. 22).

According to Hussain (2019), the tremendous innovations, as well as increased patronage in libraries have ushered in a new era dominated by 4IR technology, which is a collection of technologies that may be used to replicate or outperform tasks performed by humans using machines. These technologies have unquestionably yielded extraordinary results. It now means that jobs that were formerly thought to be impossible to automate are now well within computers' capability (Tella, 2020). In the advanced world, AI, robotics, cloud computing, and

IoTs had been introduced into academic libraries, making them smarter, boosting staff job capacities, satisfying consumer expectations, and bridging the knowledge gap, all of which had a significant positive impact (Gul; Bano, 2019). IOTs encourage the convergence of a variety of things, such as RFID tags, sensors, actuators, networked devices, and others, that can communicate over different addressing systems to achieve common goals (Sarhan, 2018). RFID technology is currently being used in Bangladeshi libraries (Saibakumo, 2021). In addition, the University of Pretoria in South Africa is the first library in Africa to deploy a humanoid robot named "Libby" in its services (Kim, 2017).

As evident from the literature, academic libraries in developed countries are already benefiting from the integration of 4IR technologies in their operations and services; nevertheless, many academic libraries in Nigeria and other African countries have yet to find their feet (Abayomi *et al*., 2021). Could it be that Nigerian academic libraries are unaware of the transformations brought about by 4IR technologies, are they finding it difficult to respond to new global trends in library services, or fearful of being replaced by these technologies? It is against these backdrops' that this study seeks to investigate the development trends of ICT applications in Nigerian Libraries and the need to consider the 4IR technologies. Although there have been numerous articles written about the need to investigate the direction of 4IR technologies' application in library operations and services, there appear to be few or no empirical studies in Nigeria that directly address the need to investigate the integration of 4IR technologies in Nigerian libraries.

2. OBJECTIVES OF THE STUDY

The broad objective of the study was to trace the development process in the application of ICT in Nigerian libraries and the need to look in the direction of 4IR technologies. The specific objectives of the study were to:

1. identify the ICTs that have been applied in libraries since the beginning of 1960.
2. identify traditional or old services Nigerian libraries were using ICT to facilitate.
3. identify ICTs that are currently being applied in Nigerian libraries and the services they are using them to render.
4. Determine the expediency of looking in the direction of 4IR technologies.
5. Identify the 4IR technologies that Nigerian libraries should apply and will apply in the future.
6. Identify the challenges Nigerian libraries encountered, are encountering, and will be encountering in the application of ICTs in libraries.

3. LITERATURE REVIEW

The libraries comprise digital components that are either old or new. The old ones are those in existence before and during the internet revolution; while, the new ones are the ones ushered in by the fourth industrial revolution. There is no doubt that digital technologies now permeate every aspect of our lives including homes, schools, workplaces, public spaces such as transport stations, libraries, cafes, cities), and government. Emphatically, it is difficult to get away from these technologies in the course of information dissemination by libraries. Faithtech Institute (The Post Modern Bible Blogs, 2020) postulate that “even those who continue to resist computer, faxes, email, personal digital assistants, let alone the internet and the World Wide Web, can hardly avoid taking advantage of the embedded microchips and invisible processors that make phones easier to use, cars safer to drive, appliances more reliable, utilities more predictable, toys and games more enjoyable and the trains run on time” With this development,

and the transformation brought by the 4IR and its associated technologies which have entered into the libraries such as artificial intelligence, AI, robotic technology, virtual/augmented reality, big data, blockchain, cloud computing, and the likes have all brought changes into the libraries.

Without a doubt, this disruption is affecting every aspect of libraries. Before the advent of the 4IR era, library services were typically traditionally provided to users. Libraries have long provided a variety of services to their patrons, including organising their collections for ease of access and availability, developing tools to inform users about the document resources available, and assisting users in obtaining whatever information they require (Agyeiku, 2021). The provision of primitive library services was never hampered by a lack of electricity or faulty telecommunications equipment (Dina, 2014). Despite being slow, outdated, and taking up a lot of space, records stored on cards and in catalogue cabinets in libraries have persisted for several years, leading users to the library's stock. In a traditional library setting, the library infrastructure is more akin to a temple or a museum that is old and poorly furnished, and the library's resources are primarily books and magazines that are only available in printed form, and the major apparatus for accessing the library's resources are old catalogue cards (Chack; Prajapati; Trivedi, 2017).

The bottom line is that 4IR technologies are now being used across many domains to ensure that academic libraries continue to have an impact in this advanced technology era. These technologies are already recognised as important advanced information technology that can be used in a variety of industries, but libraries in Nigeria are only now beginning to pay attention to them. In libraries, 4IR technologies are likely to have a significant impact on search/resource discovery and quick access to information resources. Cox, Pinfield, and Rutter (2019) identify the potential impacts of these technologies in terms of analysing large datasets, creating metadata, translating searches, assisting users in finding information, responding to user queries, and integrating search across all information contents. Using cloud computing, AI, and robotics, many academic libraries have begun to move away from library catalogues and toward online "discovery systems" in recent years (Sproles, 2022). The online catalogue evolved from physical card catalogues, in which each item in the library was organised, along with relevant metadata, to make the library's holdings findable and accessible to patrons.

The 4IR technologies, on the other hand, have a clear potential to alleviate many of these concerns. It is easy to imagine AI finding connections and patterns in existing data using the machine learning techniques described above, which would be nearly impossible for humans to replicate on a large scale. AI and the internet of things could refine data from thousands of previous searches in a variety of ways, revealing patterns based on patron behaviour. For example, these technologies may notice that patrons who search for specific phrases are more likely to be satisfied by items written for an academic audience. Furthermore, using contextual clues about the title and other existing information, it may be able to determine which items are written for an academic audience, even if that information is not included in the metadata. Some libraries have incorporated 4IR technologies into their daily operations. Books are transported from Bryant Park off-site storage to the New York Public Library basement by an innovative robotic conveyor system (Smith, 2019). Vincent and Nancy, two librarians at the Connecticut West Port Library, are in charge of teaching AI to library patrons. To analyse and use data intelligently, some libraries are using social media tools, drones, cameras, and other Industry 4.0 devices. As part of its evolution in line with the 4IR, the University of Pretoria hired Libby, a client service robot, in May 2019. According to the University of Pretoria (2019), the robot is responsible for providing instruction, conducting surveys, displaying marketing videos, and answering queries.

3.1 Theoretical Framework - Diffusion of Innovations Theory

This case study is theoretically grounded in the Diffusion of Innovation Theory by Rogers (2003). In the application of Information Communication Technology (ICT) such as the case in this study, Rogers' (2003) Diffusion of Innovations Theory (DOI) is a commonly used theoretical framework. According to the theory, not every member of a population group adopts innovations at the same time because some people are more open to experimenting with novel concepts and tools than others. The acceptance of innovations is influenced by individual characteristics like gender, age, inventiveness, and ethnicity, as well as by social characteristics like education and socioeconomic standing, as well as by technological characteristics like perceived benefits and utility (Leung and Wei, 1999). According to Rogers, the key elements of DOI theory are innovation, communication channels, time, and social structure.

According to Rogers' (2003) theory, the decision-making process for innovations is comparable to the process of gathering information, where the individual or organisation making the decision wants to lessen their level of uncertainty regarding the benefits and drawbacks of the innovation. Five steps make up this process: information, persuasion, choice, implementation, and confirmation. The individual/organisation becomes aware of the invention and looks for information on it during the knowledge stage. After learning about the innovation, the person/organisation adopts an attitude in the second step (persuasion). The information stage is more cognitively oriented, while the persuasion stage is more affectively oriented, claims Rogers (2003). The person/organisation chooses whether to accept or reject the innovation in the third step, known as the decision. The innovation is put into effect in the fourth stage, implementation, and the while at the last stage the individual/organisation seeks support regarding the decision made.

Rogers (2003) emphasised that characteristics such as (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability of the invention can help reduce uncertainty. The degree to which people/organisations (libraries in Nigeria in this case) think the invention is superior to the conventional approach is known as a relative advantage. The degree to which people (libraries in Nigeria in this case) think the invention is compatible with conventional wisdom is referred to as compatibility. The degree to which people (libraries in Nigeria in this case) find the invention (ICT) challenging to use and comprehend is measured by complexity. Trialability is the degree to which people (libraries in Nigeria in this case) think they have a chance to try out the innovation (ICT) before choosing whether or not to adopt it, and observability deals with the degree to which the innovation (ICT) results are apparent to other people (users, government and other stakeholders).

This study hinges on the application of ICT in Libraries in Nigeria. The adoption of information technologies in the environments of libraries in Nigeria has focused on the Diffusion of Innovations Theory as a theoretical paradigm. According to several scholars, the best theory to use to examine how technology is being adopted is Rogers' (Borrego, Froyd and Hall, 2010; Medlin, 2001; Parisot, 1997). There are available studies that have also focused on the application and adoption of technologies using this same theory. For instance, the use of Web 2.0 technology (Goldstein *et al.*, 2012). Bowers, Ragas, and Neely (2009); the utility of Second Life as a teaching tool among post-secondary instructors using Rogers' theory. According to Sahin (2006), Rogers' (2003) use of the relative advantage, compatibility, and complexity attributes is connected to people's perceptions of the use of instructional computers; Health IT use, Wallace and Iyer (2022); adoption of machine learning technology, Joshi and Singh (2022); flipped instruction for Information Systems (IS) courses, Sanandaji and Ghanbartehrani (2021); zoom rooms, Katz and Kedem-Yemini (2021); and virtual classrooms, Mahara *et al.* (2021). Additionally, Ntemana and Olatokun (2012) suggested that the most

important factors influencing the use of ICT were a relative advantage, complexity, and observability; however, these variables were not focused on in this study.

3.2 Empirical Review

Several studies have been conducted to investigate the state of ICTs in Africa, particularly Nigeria (Alemna and Sam, 2006; Omoniwa, 2001; Oketunji, 2000). Alemna and Sam (2006) investigated the availability of ICT in the University of Ghana Library (UGL) and the University of Zambia Library (UNZA), finding that ICT was introduced at UGL and UNZA at different times and in different ways. Their research revealed that both libraries have CD-ROM, e-mail, and internet services. From 1972 to 2001, Omoniwa (2001) tracked the effort to computerise Kashim Ibrahim Library at Ahmadu Bello University and discussed the issues that hampered the project. In their study, Oketunji (2000) were interested in determining the current state and future of ICT in Nigerian libraries and information services. Ebunuwele, Ola and Uduebor (2014) noted that between 1965 and 1968, a computer was used by the Library of Congress to produce "machine-readable catalogue records." MARC I was started by LOC, and MARC II was quickly followed. MARC II was designed as a way of "tagging" bibliographic records using three-digit numbers to identify fields.

In a study conducted by Ubogu (2019) on the Impact of information technology in Nigerian University libraries, Findings show that ICTs are mostly used for acquisition and cataloguing processes and circulation routines, ICTs facilities are used in the library because they are easier, and faster and save the time of librarians. Also, Ivwighreghweta (2013) surveyed the application of ICT on library operations and services in selected academic libraries in Nigeria. The study's major findings revealed that internet access and computers were available in the chosen libraries. The main reasons for using the ICT facilities in the selected libraries were revealed to be that students and researchers use them for internet browsing and preparing lecture notes. It was also discovered that the services and operations in libraries where ICT is most commonly used are material acquisition and provision of OPAC services, reference services, cataloguing and classification and acquisition of information resources. Meanwhile, the result of this study also shows that the majority of the respondents identified poor funding and power supply as the major problem militating against the use of ICTs in the selected libraries.

Based on publications published between 2009 and 2018, Ma *et al*. (2019) present the state of the art in AI-powered, IoT and investigate smart public services in China. Their research highlights significant research issues in the discipline as well as real-world applications, such as in librarianship. According to Schreur (2020), the shift from card catalogue to MARC formats has been extremely beneficial to libraries and their customers. Similar to connected data, AI holds the same promise. Libraries can represent their resources on the Semantic Web by converting metadata surrogates (cataloguing) into linked open data.In Nigeria recent, various studies have been carried out on the assessment of e-resources use, social media application and skills to render Information Communication Technology (ICT) services in academic libraries such as Simon and Ogom (2015); Ojeniyi and Adetimirin (2016) while Asogwa, Ugwu and Ugwuanyi (2015) evaluated the quality of online services in academic libraries in Nigeria as regards the functionality of electronic infrastructures. Libraries strengthen overall user experiences by having a customer value-based services perspective to keep a larger “share of customers” (Weinstein and McFarlane, 2017).

Walmiki and Ramakrishnegowda (2009), studied ICT infrastructure in university libraries in Karnataka and found that most of the libraries were lack sufficient hardware, software facilities and do not have adequate internet nodes and bandwidth. The campus LANs were not fully extended to exploit the benefits of the digital information environment. Ahmad and Fatima

(2009) found that researchers use a variety of ICT products and services for research and further remarked that ICT facilities such as the internet, and products help “to find information, access information more easily”. It was recommended that training be organized to increase the use of ICT-based products and services. Shafi-Ullah and Roberts (2010) found ICT infrastructure and recommended allocating funds for ICT infrastructure. Sivakumaren, Geetha and Jeyaprakash (2011) stated that University Libraries must increase the number of computers available to enable the users to maximize the usage of ICT-based resources and services and it is found that no library was implemented digitization software. It is very useful to digitize rare collections such as older and out-of-print editions. Mairaj and EI-Hadi (2012) found that the Provision of hardware, standardized Library software, adequate financial resources, and proper training facilities for medical libraries will help to strengthen ICT applications in the Medical Libraries of Lahore.

Odeyemi (2019) stated that Nigerian libraries are completely prepared to integrate new technologies such as robots into the library service delivery system, even though some constraints, such as technophobia, preclude this possibility while they wait for emerging technology to be adopted. Lack of finance, ICT personnel shortages, and insufficient power supply, according to Otunla (2016), are all obstacles to utilizing new technologies like library management software. Other issues have been raised, and they must be investigated and addressed for new technologies to be completely adopted in Nigerian academic libraries. Inadequate technical personnel, the complexity of the technological interface, poor bandwidth, and increasing user expectations have all become key challenges for most libraries, (Omosor, 2014). Anyim (2021) previously said that skill development and training in information and communication technology (ICT) are necessary for new technology to be integrated into Nigerian libraries, as it poses a danger to library services.

Rimland (2019) discussed the application of AI to aid with micro-credential assessments. It covers the Pennsylvania State University Libraries' micro-credentialing initiative, the growth in the number of micro-credential submissions, and how micro-credentials give evidence of education in granular abilities. Based on direct interviews, Cox, Pinfield and Rutter (2019) provide the perspectives of library directors, library critics, and specialists in education and publishing on the possible influence of AI on academic libraries and its consequences for library work. AI has been highlighted as influencing search and resource finding, scholarly publication, and learning, according to the respondents. Libraries being left out of development, ethical issues, decision intelligibility, and data quality are among the challenges they've discovered. Academic libraries might play a variety of functions, including data gathering and curation, AI tool acquisition and infrastructure development, user navigation, and data literacy.

In a study conducted by Griffey (2019), data security and privacy concerns push libraries to incorporate AI into their system and services. Williams (2019) characterizes Amazon's Alexa, Apple's Siri, Microsoft's Cortana, and Google's Assistant as AI-powered assistants that help people find information in their daily lives. Although these assistants were designed for consumers rather than librarians, they can be utilized to improve database search operations and help academics discover what they're searching for more quickly. Wheatley and Hervieux (2019) did an environmental scan on academic libraries' AI involvement by analysing scholarly papers, university libraries' strategic plans, and library programs to see if AI was mentioned and in what context. Though a limited number of institutions were discovered to be engaging in or building their own AI centres, the findings revealed a lack of responsiveness or awareness to the present AI trend. AI enables big data applications, machine learning algorithms, deep learning, knowledge discovery, neural networks, and other technologies by combining AI with the Internet of Things (IoTs) in a variety of ways.

4. DESIGN AND METHOD

This section describes the method adopted to carry out the study on the case of the application of ICT in libraries in Nigeria. It includes the design, population, sample, and instrument for data collection, the procedure of administration, data analysis, and presentation of results**.** The study adopted a purely qualitative method. The qualitative method focuses on obtaining data through an open-ended survey. Qualitative methods usually give room for in-depth and additional probing and questioning of respondents based on their responses, where the respondents and or researcher try to understand their motivation and feelings. Understanding the perspectives of librarians on the development of ICT applications in Nigerian libraries and the need to look into the direction of 4IR technologies will help to derive a conclusion in the study.

A qualitative method was chosen because it is assumed to help reveal the perception of librarians in libraries regarding the subject matter of the study which focuses on the development process in the application of ICT in Nigerian libraries and the need to look in the direction of 4IR technologies. Similarly, the design was chosen because the results are usually more descriptive and the researcher can draw inferences from the data obtained from the respondents. Also, the qualitative method is inexpensive especially when it is self-administered. The use of an open-ended survey in this study enabled the researcher to gather relevant data. Though many types of qualitative methods are available (Creswell and Poth, 2018), however, the open-ended survey was embarked upon because it is one of the most common qualitative research methods; and because it is considered the most practicable method during this pandemic period where social distancing is being observed.

4.1 Population and Sample

The population for the study comprised academic librarians from all the Federal Universities in the six geo-political zones of Nigeria. Currently, there are 44 federal universities in Nigeria (NUC, 2020). One Federal university was selected from each of the six zones, and the library in each of these universities was chosen. This makes a total of six libraries that took part in the study. The six selected libraries are located in the following states: Cross River (University of Calabar library), Enugu (the University of Nigeria Library), Lagos (University of Lagos library), Kano (Bayero University library), Kwara (University of Ilorin library), and Gombe (Federal University Kashere Library). The study did not extend beyond the selected six libraries from the six geopolitical zones because of the ongoing Academic Staff Union of Universities (ASUU) strike across the nation. The study targeted academic librarians particularly system librarians and librarians experienced in the use of ICT. From each library, TEN librarians were purposively selected; this gave a total of 60 academic librarians that represent the sample for the study.

4.2 Instrument

An open-ended survey that featured performed questions relating to the seven objectives of the study was developed. The survey featured instructions on how to respond to it and explained the concept of 4IR technologies and their relevance to libraries for the respondents to have a good understanding of what it is. The items in the open-ended survey are those that are relevant in capturing data on the five variables focused on the objectives of the study.

4.3 The Procedure of Administration

Respondents were meant to be reached individually for an interview to be conducted by the researcher but as a result of security reasons and the looming ongoing national crisis across the country necessitated the researcher against administering the interview. Instead, an alternative arrangement was made with the contact person in each of the libraries and this resulted in preparing an open-ended questionnaire (survey) through an online platform (Google Form) that was sent to the respective respondent's contact. The respondents were asked to fill out the survey and return it to the researcher at the earliest possible time. Regarding ethical considerations, informed consent from the respondents was sought and each of them delightedly expressed their intention and willingness to take part in the study. Similarly, they were allowed to withdraw their participation provided they thought their involvement might prove otherwise. Out of the 60 copies of the survey mailed to the respondents, 38 were returned filled, and good for the analysis. The breakdown of the returned survey is presented in Table 1.

Table 1. Survey Administration and Return Rate

S/N	Geopolitical Zones	Chosen States	Chosen Libraries	No of Survey Administered	No of Survey Returned
1.	North-Central	Kwara	University of Ilorin Library	10	8
2.	North-Eastern	Gombe	Federal University Kashere Library	10	5
3.	North-Western	Kano	Bayero University Library	10	5
4.	South-Eastern	Enugu	University of Nigeria Library, Nsukka	10	7
5.	South-South	Cross River	University of Calabar Library	10	6
6.	South-Western	Oyo	University of Lagos Library	10	7
Total				60	38

Source: Field Survey (2021)

From the table, 38 copies of the open-ended survey were returned out of 60 copies that were administered. This represents a 63.3% return rate. The returned copies of the open-ended survey were sorted, collated, and transcribed by the researcher and reported accordingly.

5. RESULT

This section detailed the results obtained from the analysis and transcription of the data collected through the open-ended survey. The results are hereby presented thematically:

5.1 ICTs application in libraries beginning from 1960

The librarians were asked to list the information and communication technologies (ICTs) that have been used in libraries since 1960. In general, few responders stated clearly that Machine-Readable Cataloguing (MARC) had been in use since the beginning of 1960 until the 1990s, when catalogue cards were changed into Online Public Access Catalogue (OPAC): For example, one respondent reported that:

> *"OPAC has been widely embraced by many academic libraries, in short, multiple libraries, including my library, are still using OPAC. The OPAC facilitates users' access to and use of information resources. OPAC, as one of the earliest ICTs used in libraries, has grown in popularity in the field of librarianship, and most academic libraries are still using it to efficiently serve patrons, thanks to the advent of the internet, which has made OPAC possible."*

> *"Reprographic Technology is another ICT tool that is widely used in academic libraries around the world*," another responder said, *echoing the same comment. This technology is available in libraries to facilitate on-demand duplication/photocopying of documents. It is, without a doubt, one of the most wonderful technologies available in libraries. Before the emergence of Electronic Information Resources (EIRs), this technology was very effective in duplicating information resources. However, it is believed that this technology is no longer widely employed because it has been superseded by other technology such as Smartphones."*

Similarly, 29 out of 38 responses confirmed that telephones, computers, and storage devices such as magnetic discs, floppy diskettes, Compact Disks (CD), printing technology such as printers, microfilming machines, fax, and scanning machines are among the most popular ICTs used in libraries.

The results indicate that many ICT facilities were used in library operations and services beginning in 1960, including computer systems, electronic mail, MARC, OPAC, reprographic technology (photocopier machine), printing technology (printers), storage devices (Floppy Disk, Compact Disc), microfilms, facsimile machines, and scanning machines, and that some of these facilities are still in use today. Many of these ICT facilities, on the other hand, are still in use in many university libraries around the world. This finding is consistent with Ebunuwele, Ola, and Uduebor's (2014) claim that the Library of Congress utilised a computer to produce "machine-readable catalogue records" between 1965 and 1968. LOC initiated MARC I, which was immediately followed by MARC II. MARC II has been created as a technique of "tagging" bibliographic records by identifying fields with three-digit numbers.

5.2 Traditional or old services Nigerian libraries were using ICT to facilitate

Librarians were asked to relate and indicate based on their experiences on the traditional or the old service Nigerian libraries were using ICT to facilitate. The majority of the academic librarian noted that:

> "*When it comes to satisfying the information need of the clients, libraries implement an ICT-based interlibrary lending system, through the use of electronic networks for document delivery. In essence, the Document Delivery Service (DDS) enables a library to use copies of research papers or other research documents, from other libraries. These documents could be digital journals/articles or other documents. They are mostly in PDF format and are*

supplied to library users' computers via e-mail and computer systems. This service, however, is referred to as Electronic Document Delivery."

In other words, a few librarians also added this**:**

"Libraries are also providing access to web-based Online Public Access Catalogue (OPAC) interfaces. The OPAC makes it easier for users to access and use information resources. OPAC is the computer form of the library catalogue, to access materials in the library. This kind of service is called the provision of web access to OPAC."

The majority of the respondent also noted:

"*The telephone, email, and fax machines have become particularly effective technologies for disseminating information to library customers when it comes to "reference service management." "We all know how difficult it is for most information users to get critical information from the library," so communicating via these medium makes it easier for both users and the librarian."*

Another respondent also noted:

"One of the functions that ICT is used for is the preservation of library resources. However, preserving and archiving manuscripts and ancient writings, as well as making them secure for future use, is a challenging chore in libraries. Computers, scanners, and storage devices are used to carry out this activity. Using computers, published write-ups can be converted to digital form and then stored on computer hard discs and other media such as CDROM and DVD. As a result, Digital Repository software aids in the storage and retrieval of digital objects like documents, images, audio/video clippings, and metadata."

The result implies that the old services offered by libraries through ICT include Document Delivery Services (DDS), Provision of web access to OPAC, Preservation of library resources and duplication of information resources to various formats (Document Scanning Services), and Interactive search services, based on the responses obtained from the librarian. This finding is consistent with Ivwighreghweta's (2013) research on the impact of ICT on library operations and services in Nigerian academic libraries. The study's main findings revealed that the selected libraries had internet access and computers, which are two of the most common ways for libraries to provide online services. Students and researchers, use the ICT facilities in the selected libraries primarily for internet browsing and preparing lecture notes, according to the findings. Material acquisition and provision of OPAC services, reference services, cataloguing and classification, and acquisition of information resources are among the services and operations in libraries where ICT is most commonly used.

5.3 ICTs that are currently being applied in Nigerian libraries and the services they are using them to render

Based on responses to the questions, respondents were asked to identify the ICT currently used in Nigerian libraries and the services they are providing. Libraries in Nigeria have used a variety of ICT facilities to improve library services, according to a few respondents. Many ICT are now used in Nigerian libraries, and the services they provide vary depending on the library environment.

According to a respondent:

> *"Most library users are scanned as they leave the library by a theft detection system because all information resources must be protected at all times to ensure their availability and continuous accessibility."*

Another respondent noted also that:

> *"Social media has been a major source for libraries to communicate with the environment about new arrivals at the library or current events at the library."*
>
> *"Social media allows the library to reach out beyond its desk and into the lives of its users, allowing it to become a part of their services."*

Another respondent also noted that:

> *"The use of ICT tools such as Facebook, Skype, Wikis, WhatsApp, E-mail, SMS Text Messaging, RSS Feed have helped libraries and librarians to serve their users better by reaching them with the required information outside the library"*

Few respondents had a common view that:

> "*Computer systems are valuable management tools that can help improve the efficiency of a variety of library activities. It can be used for a variety of tasks and services, such as data generation, processing, storage, analysis, transformation, and dissemination to clients. The computer saves the information it analyses on CDs, flash drives, and other computer equipment. Also, Computer systems are used for a variety of library tasks, such as ordering/acquisition, circulation, and so on, thanks to the power of their peripherals."*

The findings reveal that the majority of respondents use a variety of ICT, including the internet, social media, e-mail, video conferencing technology, telephone, television, computer hardware/library automation software, network hardware, peripherals, internet connections, and digital technologies such as barcode machines for book scanning and theft detection systems, among others. According to Sivakumaren, Geetha, and Jeyaprakash (2011), University Libraries must increase the number of computers available to enable users to maximise the use of ICT-based resources and services, and no library has implemented digitization software. Rare collections, such as older and out-of-print editions, benefit greatly from digitization.

5.4 The expediency of looking in the direction of 4IR technologies

The respondents were asked to indicate the importance of looking in the direction of 4IR technologies for library operation and services based on the librarian's perception of whether it is a good idea to look in the direction of 4IR technologies. The majority of respondents agreed that libraries in Nigeria have positive feelings about the indispensability of 4IR technology for library service, according to the findings. Some respondents identified libraries in other African countries with a similar background to Nigerian libraries, such as Kenya, Ghana, and South Africa, that have implemented sophisticated technologies to demonstrate their readiness to integrate 4IR technologies into library operations and services.

While justifying the expediency of looking into the direction of 4IR technologies, many explanations were offered. For instance, a respondent indicated:

> *"4IR technologies have completely transformed how librarians live, work, and interact with their users, and they have become a game-changer for the entire industry."*

A few respondents also indicated that:

> "*If librarians look in the direction of 4IR technologies, they will become more powerful and make more informed decisions. Librarians will also be able to solve more difficult problems and do a better job. The power of connecting data and people has been combined in this revolution, and the power of a click on the internet has assisted librarians in solving many problems."*

In a related vein, another respondent has this to say*:*

> *"Yes, I agree that 4IR technologies have become a game-changer for all industries, including libraries, but the reality is that it has become the norm, and most libraries in advanced countries are reaping the benefits." It is a pity that Nigerian libraries are lagging in seizing this opportunity, owing to the potential for changes that would affect the library and necessitate them upgrading their skills to keep up with the revolution. Some of these few were unable to effectively manage technology to meet the demands of library users."*

Few respondents also noted that:

> "*The most amazing aspect of these 4IR technologies is how they have changed the way library graduates look for work. All graduates now want to learn new skills related to 4IR technologies, such as learning a programming language, machine learning, big data analytics, data science, deep learning, and many others. These are all ways to get everyone ready for the technological revolution ahead of time."*

Another respondent has this to say:

> *"Yes, I agree that Nigerian libraries are not yet ready to consider looking at the direction of 4IR technologies." This is because only a few libraries in Nigeria have implemented cloud computing into their operations and services. Some of these few were unable to effectively manage technology to meet the demands of library users and again they simply want to establish an online presence but are unable to meet their obligations due to technological limitations."*

A respondent noted that:

> *"The majority of these libraries are still dealing with issues such as poor power supply, a lack of skilled manpower to handle ICT equipment maintenance, and a lack of budgetary allocation to procure ICT equipment that will foster the application of these 4IR technologies." Based on the aforementioned challenges, there is a very slim chance of looking into 4IR technologies."*

The results show that the vast majority of respondents recognise and comprehend the importance of 4IR technologies. Few respondents said they had personally experienced the significance of these technologies in the advanced world, while others said they had read about it in the literature and heard about it at conferences and seminars. Without a doubt, 4IR technologies are changing the world landscape, and they have redefined how libraries in the

advanced world interact with their patrons. The benefits of looking into the direction of 4IR by libraries are unquantifiable, according to the findings, because it has become a game-changer for the industries at large, including libraries, and it has also become the order of the day, with these technologies already working side by side with robots and other automated technologies such as AI, IoT, and cloud computing technologies, among others. These findings support Smith's (2019) argument that libraries in the advanced world have adopted 4IR technologies in their day-to-day operations. A sophisticated robotic conveyor system transports books from the off-site storage area at Bryant Park to the New York Public Library underground. Vincent and Nancy, two librarians at the Connecticut West Port Library, are in charge of teaching AI to library patrons (robots). To analyse and use data intelligently, some libraries are using social media tools, drones, cameras, and other 4IR technologies. The robot is also in charge of giving instructions, conducting surveys, showing marketing videos, and answering questions.

5.5 The 4IR technologies' that Nigerian libraries hope to apply in the future

In comparison to the current ICT available in libraries, respondents were asked to identify and suggest 4IR technologies that Nigerian libraries might use in the future. Respondents indicated that libraries could use a variety of 4IR technologies, according to the findings. Cloud computing, Makerspace, AI, and Robotics are among the technologies mentioned most frequently by respondents. Few respondents expressed mixed feelings about whether or not libraries should or will use 4IR technologies.

However, few respondents indicated that:

> *Not all Nigerian libraries are prepared to implement 4IR technologies now or in the future. To back up this claim, a response stated, "Not all academic libraries in Nigeria are ready; in fact, I would say that the majority of public libraries and some academic libraries in Nigeria are not ready." This is because these libraries are under-equipped with ICT facilities and it is clear that those that are available are not being properly maintained; in fact, most academic library staff have a negative attitude toward using basic ICT to deliver library services. As a result, I do not believe Nigerian libraries are ready to implement any of these 4IR technologies in the future, except a few private libraries that have demonstrated some seriousness in implementing some of these technologies, such as cloud computing and robots in their services."*

Academic libraries in Nigeria have expressed interest in incorporating 4IR technologies into their operations, according to some respondents. Most libraries are not automated, according to these respondents, except for a few academic libraries that have attempted to integrate new technologies such as cloud computing, social media, closed-circuit television, e-resources, and online databases to improve their services. For instance, a respondent indicated that:

> *"No academic library in Nigeria has introduced AI system, robotic technology, internet of things, and the likes into their operations and services except for University of Lagos library only that has integrated robotic technology into their library operations and services, therefore, I will say that other universities that share the same background as University of Lagos might likely emulate the same stand."*

As evidenced by the reviewed literature, many libraries in the United States, the United Kingdom, and Australia have implemented sophisticated technologies to demonstrate their readiness to implement 4IR technologies, such as AI systems, into their library systems. Other developed/developing countries that have not yet implemented robotic technology, the internet

of things, cloud computing, and other technologies into their library systems are currently doing so. In Africa, the fact that Libby and Markerspace are now being used at the University of Pretoria in South Africa, according to Ocholla and Ocholla (2020), reflects the fact that those academic libraries have advanced far ahead of those in Nigeria. Furthermore, Odeyemi's findings revealed that Nigerian academic libraries are gradually adopting other technological frameworks to provide library and information services, indicating that there is a higher likelihood that Nigerian libraries will progress.

5.6 Challenges Nigerian libraries encountered in the application of 4IR technologies in libraries

Respondents were asked to list any challenges they might face if or when 4IR technologies are implemented in libraries. According to the findings, respondents have identified any challenges that they may face when implementing 4IR technologies in libraries. Poor maintenance culture, insufficient experts, poor power supply, poor internet service and a limited budget to procure other technologies that will help the 4IR technologies run smoothly are among the challenges identified.

Other explanations and the identification of challenges that libraries may encounter in the application of 4IR technologies are hereby summarised as a follow-up to the aforementioned submissions.

Few respondents noted that:

> *"Adjusting to the new paradigm shift in the application of 4IR technologies may pose a challenge for librarians." Why? Because most of the Nigerian libraries I am familiar with are not technologically savvy when it comes to performing their functions. The majority of these librarians rely heavily on the I.T. personnel working in the E-library session to complete some specific ICT tasks."*

Another respondent noted that:

> *"Academic librarians may reluctantly or outright refuse to accept the technology due to a fear of change in the library system, i.e., librarians may be afraid to work side by side with these technologies to avoid exposing their flaws if it is eventually integrated into the library system."*

A few respondents also submitted that:

> *"As a result of the cost of procuring and maintaining the technology, only a few academic libraries in Nigeria are ready to integrate 4IR technologies into their operations and services." The fact is that the number of automated academic libraries is currently limited. In libraries that are not fully automated, some of these technologies may not work perfectly. As a result, to keep up with current global practices, academic libraries must consider the installation of sophisticated ICT infrastructure. Except for the University of Lagos Library, Covenant University Library, Landmark University Library, and a few academic libraries in the country, no library in Nigeria is currently using any of these 4IR technologies to provide services to information users. As a result, I do not see libraries in Nigeria getting there anytime soon."*

These findings agree with Saibakumo's (2021) report that unreliable power supply, inadequate technology infrastructure, a lack of technical skills, a poor attitude toward advanced automation, the use of inappropriate library software, and technophobia are among the

challenges faced by academic libraries in integrating AI systems into library operations and services. The findings also support the findings of (Wheatley and Hervieux, 2019), who all identified skills mismatches and a lack of relevant skills as a challenge facing academic libraries.

5.7 Theoretical Implications of the Development of Libraries in Nigeria

5.7.1 Technological Determinism

One theoretical implication of tracing the development of ICT in Nigerian libraries is technological determinism. This theory argues that technology drives social change, and the development of ICT has had a significant impact on Nigerian libraries (Nwani, Effiong, & Matthew, 2022). The evolution of ICT in Nigerian libraries has brought about significant changes in the way libraries operate, and this has affected the nature of library services, resources, and collections.

5.7.2 Diffusion of Innovation

The diffusion of innovation theory is another theoretical implication of tracing the development of ICT in Nigerian libraries. This theory suggests that the adoption and diffusion of new technologies are influenced by various factors such as compatibility, relative advantage, complexity, and observability. The adoption of ICT in Nigerian libraries has been influenced by factors such as funding, infrastructure, training, and staff readiness, which have affected the pace and extent of adoption.

5.7.3 Information Society

Tracing the development of ICT in Nigerian libraries also has implications for the Information Society theory, which posits that technology has transformed society into a new era characterized by a proliferation of information and communication technologies. The application of ICT in Nigerian libraries has enabled them to provide better and more efficient services to users, and this has contributed to the transformation of the library into a hub of information, knowledge, and communication (Ahmed and Sheikh, 2021).

5.7.4 Social Construction of Technology

The social construction of technology theory is another theoretical implication of tracing the development of ICT in Nigerian libraries. This theory argues that technology is not neutral but is shaped by social forces such as politics, culture, and economics. The application of ICT in Nigerian libraries has been influenced by various factors such as government policies, funding, and the needs of users, which have shaped the nature and extent of technology adoption (Hamad, Al-Fadel and Shehata, 2023). To this end, tracing the development of ICT applications in Nigerian libraries has several theoretical implications that highlight the complex interplay between technology and society. Smidt and Jokonya (2022) opined that technology adoption is not a linear process, but is shaped by various factors and that the impact of technology on society is multidimensional and dynamic.

6. CONCLUSION

The study looked at the evolution of ICT applications in Nigerian libraries, as well as the need to look into the direction of 4IR technologies. MARC, OPAC, reprographic technology, printing technology, Scanner Machines, Storage technology such as floppy disc and CD, microfilms, facsimile machines, e-mail, and the internet were among the ICT identified in the findings. Document Delivery Services (DDS), Provision of web access to OPAC, Preservation of library resources and duplication of information resources to various formats (Document Scanning Services), and Interactive search services are some of the older ICT services provided by libraries. The internet, social media, e-mail, video conferencing technology, telephone, television, computer hardware/library automation software, network hardware, satellite systems, peripherals, internet connections, and digital technologies like barcode machines for book scanning and theft detection systems, among others, have all been used by libraries. Many libraries have also used social media to promote library services, and this is done primarily through the use of computer systems. The benefits of libraries looking into 4IR are unquantifiable because it has become a game-changer for libraries, and librarians in the advanced world are already working side by side with robots and other automated technologies such as AI, IoT, and cloud computing technologies, among others. Robots, the internet of things, and cloud computing are some of the 4IR technologies that Nigerian libraries should use and will use in the future, based on what other libraries around the world have done. Poor maintenance culture, insufficient experts, limited power supply, and a limited budget to procure other technologies that will allow the system to run smoothly are all challenges that academic libraries in Nigeria may face when implementing 4IR technologies in libraries.

7. RECOMMENDATIONS

As a result of the findings of this study, the following are recommended:

- It is suggested that budget allocations for libraries should be increased to obtain the necessary ICT to improve library services.
- There is a need for libraries to improve on the old services offered through the use of ICT with 4IR technologies.
- Academic librarians and other library personnel must change their attitudes to improve the services they provide using ICT, and those who refuse to change their attitudes toward accepting the use of ICT may be asked to resign from their positions.
- There is a need for librarians to be adequately educated on the capabilities of using 4IR technologies in libraries. In Nigeria, adequate funding for libraries is required. Funding should come directly from the government or the parent institutions of academic libraries. The majority of library staff lacks the necessary skills to operate 4IR technologies. As a result, librarians must become proficient in the use of 4IR technologies to overcome their fear of the unknown when it comes to the technology's application.
- In terms of 4IR technology adoption, Nigerian libraries must compare themselves to all other contemporary libraries in the advanced world, as well as ensure that the necessary 4IR technologies, such as AI/robots, makerspaces, IoTs, and many others, are implemented for library service improvements.
- The issue of power and poor internet service, which are both major challenges in Nigerian settings when it comes to technology adoption, should be addressed properly. This can be accomplished by putting in place alternative power generators and relying on a reputable internet service provider. Alternative solutions such as solar power, biofuel for power generation, and the like can also be considered by libraries in Nigeria.

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