

**An Assessment of the Effect of the Fourth Industrial Revolution on Library
Services: A Case of Academic Libraries in Lusaka Province**

By

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**A Thesis submitted to the University of Zambia in fulfilment of the award of the Degree
of Doctor of Philosophy in Library and Information Science**

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Declaration

I, Kadeyo Mutale Kuyela, hereby declare that this Thesis, entitled “*An Assessment of the Effect of the Fourth Industrial Revolution on Library Services in Selected Academic Libraries,*” is my original work and has not been submitted to any institution previously. All sources used have been thoroughly acknowledged.

Signed (Candidate)..... Date..... 2025

Certificate of Approval

This Thesis by Kadeyo Mutale Kuyela is hereby approved as partial fulfilment for the award of the Degree of Doctor of Philosophy in Library and Information Science.

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Dedication

This work is dedicated to my adorable wife Chipu Kuyela Chembo, my mother Anastasia Mutale Kuyela, my Uncle Francis Kuyela, my children, Daniel Lupalo Mutale Kuyela, Nehemiah Mutale Kuyela, Simeo Kuyela, Nathaniel Mutale Kuyela, and my brother Pascal Mutale Kuyela for their diligent support during the period of writing this dissertation.

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May God bless you all!

Abstract

The Fourth Industrial Revolution (4IR), which is characterised by a fusion of physical, digital, and biological technologies, has profoundly influenced various sectors, including academic library services. This study assessed the effect of 4IR technologies on library operations within academic libraries in Lusaka Province. The study adopted the positivist philosophical approach and a descriptive survey design, data was collected from 106 librarians through stratified random sampling. Responses to closed-ended questionnaires were analysed using descriptive statistics, and hypotheses were tested using the Chi-square test at a 0.05 significance level. The study revealed that libraries are becoming increasingly aware of Fourth Industrial Revolution (4IR) tools, with technologies such as digital repositories accounting for 28.3% and artificial intelligence for 18.9% of the identified innovations

The findings indicated that while several Library 4.0 (LIB4.0) technologies had been integrated into library services, the adoption remained low. Common technologies included AI-enhanced cataloguing systems were adopted by 37% respondents in their libraries while 21.7% of the libraries were chatbots showing a disparity between the potential of these tools and their actual utilisation in daily library operations. This uneven adoption suggests that while libraries recognise the value of such technologies, challenges in full integration and effective usage persist. However, innovations like blockchain and robotic automation were minimally explored, accounting for only 18%. Data analytics, cloud computing, and big data were underutilised, with 63.2% of respondents reporting not using them in decision-making.

The study also highlighted librarians' growing confidence and skill levels in leveraging emerging technologies. Approximately 85% of respondents reported confidence in using digital library management systems, with 51% frequently engaging in professional development. However, gaps in training and limited exposure to advanced tools like virtual reality (VR), augmented reality (AR), and blockchain persisted. These challenges emphasised the need for ongoing training programs to enhance librarians' proficiency in 4IR technologies and bridge knowledge gaps in emerging areas.

The results of the Chi-Square tests conducted on various factors influencing the adoption of 4IR technologies in academic libraries indicate significant relationships between these factors and adoption. In the first analysis, the perceived usefulness of 4IR technologies was found to have a significant impact on their adoption, as evidenced by a Chi-Square value of 11.376 ($p =$

0.000). Similarly, the perceived ease-of-use (PEOU) was also significantly related to adoption, with a Chi-Square statistic of 25.772 ($p = 0.000$), indicating that users' perceptions of ease-of-use influenced their willingness to adopt 4IR technologies. The results from the attitude towards using 4IR technologies further confirmed this, with both the Pearson Chi-Square and Likelihood Ratio statistics (8.088 and 9.552, respectively, $p = 0.000$) showing a strong association between attitude and adoption.

The study established that integration of 4IR technologies in academic libraries faced significant challenges, including financial constraints (44.3%), inadequate training programs (20.8%), and resistance to change. Additional obstacles, such as limited infrastructure and concerns about job displacement, further hindered adoption. These findings underscored the importance of a multifaceted approach to address technical and human resource challenges, ensuring effective implementation of transformative tools in academic library services.

The study recommended that academic libraries should invest in continuous professional development programs to equip librarians with the necessary skills to leverage 4IR technologies effectively. Since 85.8% of respondents acknowledged enhanced remote access, the study recommends that academic libraries should further develop and refine their digital collections to ensure seamless access for users. This could include improving the user interface of online databases, expanding open-access resources, and implementing stronger cybersecurity measures to protect digital assets. Academic libraries should prioritise budget allocations for the adoption of 4IR technologies in libraries. This could involve securing government grants, forming partnerships with technology companies, or exploring alternative funding sources such as research grants and donor contributions.

Keywords: *Fourth Industrial Revolution (4IR), Librarians, Infrastructure, Ministry of Education, Blockchain Technology, Artificial intelligence and Service delivery*

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List of Abbreviations

AI	:	Artificial Intelligence
ALA	:	American Library Association
AR	:	Augmented reality
ARL	:	Association of Research Libraries
BCE	:	Business Coalition for Education
BD	:	Big Data
CAS	:	Current Awareness Services
CS	:	Circulation Services
DOAJ	:	Directory of Open Access Journals
DPLA	:	Digital Public Library of America
DPN	:	Digital Preservation Network
4IR	:	Fourth Industrial Revolution
1IR	:	First Industrial Revolution
GCI	:	Global Competitiveness Index
HEA	:	Higher Education Authority
ICT	:	Information and Communication Technologies
IFLA	:	International Federation of Library Associations and Institutions
IJCAI	:	International Joint Conference on Artificial Intelligence
ILLS	:	Interlibrary Loan Services
ILS	:	Integrated Library Systems
IoT	:	Internet of Things
IR	:	Industrial Revolution

IS	:	Internet Services
IT	:	Information Technology
Lib 4.0	:	Library 4.0
MARC	:	Machine Readable Cataloguing
OCLC	:	Online Computer Library Center
OLH	:	Open Library of Humanities
OPAC	:	Online Public Access Catalogue
PEOU	:	Perceived Ease-of-Use
RFID	:	Radio Frequency Identification
RS	:	Reference Services
SDI	:	Selective Dissemination of Information
TAM	:	Technology Acceptance Model
3D	:	Three dimensional
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
VR	:	virtual reality
WCAG	:	Web Content Accessibility Guidelines

CHAPTER ONE: INTRODUCTION

1.0 Overview

The Fourth Industrial Revolution (4IR), or Industry 4.0, has brought about significant changes in various sectors, including academic libraries. This revolution is reshaping the roles and responsibilities of academic librarians, necessitating a re-evaluation of their competencies and skills to meet the evolving needs of patrons in today's dynamic information landscape. As technology continues to advance rapidly, academic libraries are faced with the challenge of adapting to the transformative shifts brought about by Industry 4.0. Therefore, this study aims to assess the effect of the Fourth Industrial Revolution on library services. The chapter covers the background of the study, statement of the problem, purpose of the study, study objectives, research questions, significance of the study, limitations of the study, delimitation of the study, theoretical framework, and conceptual framework. It also includes the definition of concepts and ethical considerations related to the study.

1.1 Background to the Study

The Fourth Industrial Revolution (4IR) is characterised by the integration of technologies that blur the boundaries between the physical, digital, and biological realms (Schwab, 2010). This revolution has introduced artificial intelligence, big data analytics, automation, and other innovative technologies that are reshaping traditional processes across various sectors. In the context of library services, these advancements present both challenges and opportunities for academic institutions to adapt and innovate in response to the evolving needs of their users.

The 4IR, as defined by Schwab (2015), is a technological shift that merges the boundaries between the physical, digital, and biological worlds. It involves the integration of modern technologies such as artificial intelligence, genetics, machine learning, robotics, nanotechnology, 3D printing, and biotechnology to boost efficiency and productivity across various industries. Lund (2021) also defined the 4IR as an ongoing technological shift that reshapes how people live and work by increasing automation and connectivity. According to Kamble (2018), the 4IR is the continuing transformation of society and the economy caused by the convergence of digital technologies, artificial intelligence, automation, and other emerging technologies.

Libraries, as critical institutions for knowledge transmission and access, have not been spared from the disruptive effects of the 4IR (Schwab, 2015). Anyim (2018) postulates that library services are the procedures and operations involved in maintaining, developing, and supporting library collections behind the scenes, such as acquisition, cataloguing, classification, interlibrary loan, document delivery, and serial systems as well as the shift toward the digitization of library resources and services. As digital technologies have advanced, libraries have progressively turned to providing electronic resources such as e-books, online journals, and digital archives (Kamble, 2018). This transformation not only increases the accessibility of library materials but also necessitates new skills for librarians to efficiently manage digital collections.

Furthermore, the integration of artificial intelligence (AI) and automation has transformed library operations by improving tasks such as cataloguing, search engines, and even customer support via chatbots and virtual assistants (Sony and Naik, 2020). These technological improvements have expedited operations within libraries, allowing for more efficient resource management and better user experiences. Tella and Ajani (2022) concluded that the 4IR has resulted in the introduction of new library services and spaces tailored to customers' changing demands. Academic libraries, for example, are increasingly offering technology-focused programs like coding workshops, digital literacy classes, and makerspaces equipped with 3D printers and other cutting-edge tools (Kamble, 2018).

Academic libraries, defined by the American Library Association (2000) as libraries affiliated with higher education institutions (HEIs), serve the dual purposes of supporting the curriculum and meeting the research needs of university faculty and students. Historically, these libraries have played a crucial role in facilitating access to knowledge and information resources. However, with the growth of digital materials and online platforms, the 4IR has transformed the nature of information (Grim, 2020). This transformation has compelled academic libraries to reassess their offerings and adapt their programs to accommodate users' evolving needs driven by advancing technologies.

The effect of the 4IR on academic library services is evident in several ways. Initially, there has been a shift toward digital collections and resources, with libraries progressively adopting digital platforms for organising, archiving, and providing access to a diverse range of electronic resources such as e-books, e-journals, and online databases (Echem and Lulu-Pokubo, 2022).

Furthermore, the use of automation technology has improved library operations by increasing efficiency in tasks such as inventory management and resource retrieval.

According to Sony and Naik (2020), the 4IR has revolutionised information access by allowing distant and seamless retrieval of academic texts. In Zambia, academic libraries have adopted digital repositories and online databases to ensure students and faculty have access to a wide range of academic resources at any time and from any location (Chigwada, 2021). Furthermore, advances in data analytics have enabled librarians to evaluate user preferences and behaviours, allowing them to tailor information offerings to the individual needs of library users.

Manesh (2021) revealed that the 4IR has also brought about a shift in knowledge management, from strategies focused solely on dissemination to those that promote access, knowledge sharing, and creative innovations. Academic libraries are expected to keep pace with changes in technology, which are often in a state of flux, and the constantly changing patterns of user behaviour and demand. In a similar vein, Chigwada and Kamble (2021) noted that user expectations regarding library services have shifted. Patrons now demand seamless access to a wide range of digital resources, interactive learning platforms, and personalised assistance from librarians. Libraries must align their offerings with these changing expectations to attract and retain users in an increasingly competitive information landscape.

The 4IR has redefined the role of librarians. Saharkhiz (2017) postulates that academic librarians are now required to possess digital literacy skills and expertise in navigating complex information ecosystems. They play a crucial role in guiding users through the vast digital landscape, teaching information literacy skills, and curating digital content. A study by Ayinde and Kirkwood (2020) encouraged information professionals to build up their skills and knowledge regarding 4IR technologies to thrive, even though the extent to which these innovations are adopted may differ from one library to another. Additionally, Devi and Bhatt (2023) found that technological advancements have transformed research methodology and academic support services in libraries, enabling more sophisticated literature searches, citation analysis, and research data management.

1.2 Statement of the Problem

The 4IR has ushered in unprecedented changes across various sectors, including information management in academic libraries. Isiaka et al. (2024) postulate that academic libraries, as vital hubs for knowledge dissemination and preservation, are not immune to the transformative

effects of this revolution. A study conducted by Rose (2020) revealed that as technology advances exponentially, academic libraries worldwide face increasing pressure to adapt to these changes to remain relevant and effective in delivering information services to their users. The proliferation of digital content and online platforms has revolutionised the way information is accessed and consumed. While these technologies promise to improve information retrieval and analysis, their implementation in academic libraries requires substantial investment in staff training and technological infrastructure (Nongo, 2021).

Akakandelwa and Shone (2023), in their study on students' experiences with the utilisation of 4IR technologies in online learning, found that students perceive a wide range of benefits offered by these technologies. The most acknowledged opportunities included improved use and adaptability of e-learning platforms, flexibility in learning, greater control over one's learning, more dynamic learning experiences, and the development of an education system for lifelong learning. Students also recognised the time-efficient nature of online learning, which allowed them to balance their studies with other commitments.

Despite the growing body of literature on the effects of 4IR on libraries globally, there is a dearth of research on this emerging subject in Zambia. To date, no known comprehensive study has assessed the effect of 4IR on library services in Zambia. If this study is not undertaken, the effect of 4IR technologies on library services will remain unconfirmed, unexplained, and unknown. Therefore, due to this knowledge gap, the study aimed to assess the effect of 4IR on library services in the case of academic libraries in Lusaka Province.

1.3 Purpose of the Study

The purpose of the study was to assess the effect of the 4IR on library services in academic libraries in Lusaka Province. The study aimed was to assess how the advancements of the Fourth Industrial Revolution are enhancing library services and how libraries are leveraging these innovations to remain relevant in a rapidly evolving technological landscape.

1.4 Specific Objectives

The specific objectives of the study were to:

1. Determine the extent to which academic libraries have adopted the Fourth Industrial Revolution technologies within their library services.

2. Establish how the Fourth Industrial Revolution has influenced information access and retrieval methods in academic libraries
3. Assess library staff's skills and training requirements in response to the Fourth Industrial Revolution.
4. Establish the challenges academic libraries, face in adopting Fourth Industrial Revolution technologies in their library services.

1.5 Research Questions

This study was guided by the following research questions:

1. To what extent have academic libraries adopted the 4IR technologies within their library services?
2. How has the 4IR influenced information access and retrieval methods in academic libraries?
3. What are the staff skills and training requirements of library staff in response to the 4IR?
4. What challenges do academic libraries face in adopting 4IR technologies in their library services?

1.6 Significance of the Study

This study is significant as it provides insights into how the Fourth Industrial Revolution (4IR) is transforming library services in academic institutions within Lusaka Province. As emerging technologies such as artificial intelligence, big data, and the Internet of Things (IoT) continue to reshape information management, academic libraries must adapt to remain relevant. A Study conducted by Abdullah (2020), postulates that understanding the effects of 4IR will help librarians develop strategies to enhance service delivery, improve digital literacy, and integrate innovative technologies that align with the changing needs of users. This study might contribute to the growing body of literature on the intersection of technological advancements and library services, offering policymakers and stakeholders' evidence-based recommendations for effective digital transformation.

This study is essential for library professionals, educators, and researchers who seek to understand the challenges and opportunities presented by 4IR in the academic library sector. According to Agarwal (2024), examining the adoption of smart technologies, automation, and

digital repositories will help institutions improve their information dissemination processes and optimize resource management. This study may highlight skills gaps among librarians and propose capacity-building initiatives that might ensure they remain competent in a rapidly evolving digital environment. This may ultimately enhance academic research, teaching, and learning experiences by fostering a more efficient and technologically advanced library system (Igbinovia and Osuchukwu, 2023).

This study is important because the 4IR, characterised by the integration of advanced technologies such as artificial intelligence, big data, robotics, and the Internet of Things, is rapidly transforming the way information is accessed, managed, and disseminated. Academic libraries, as knowledge hubs, must adapt to these technological advancements to remain relevant and continue supporting teaching, learning, and research.

1.7 Limitations of a Study

One major limitation of the study was its geographic focus on academic libraries within Lusaka Province. While the findings provided valuable insights into the effect of the 4IR on library services in this region, they were not directly generalizable to libraries in other provinces or countries. The socio-economic, technological, and institutional variations across regions resulted in different experiences with 4IR technologies, limiting the broader applicability of the study's conclusions.

The study faced challenges in data collection, such as the limited availability of respondents due to their busy schedules and, in some cases, their reluctance to participate. This restricted the diversity of perspectives gathered, particularly from key stakeholders such as senior librarian. Another limitation was the varying technological awareness and adoption levels among the academic libraries studied. Libraries at different stages of adopting 4IR technologies provided differing perspectives, leading to uneven representation in the findings.

1.8 Delimitations of the Study

This study focused on assessing the effect of the 4IR on library services in academic libraries within Lusaka Province. It was limited to academic libraries due to their unique role in providing research and learning resources in higher education institutions. The study did not include public, school, or special libraries, as their objectives and operational contexts differed significantly from those of academic libraries. This focus allowed for a more in-depth

exploration of how 4IR technologies were transforming academic library services, specifically in this geographic region.

1.9 Operational Definitions

As affirmed by Slife (2016), understanding how various concepts that have a bearing on the research topic are being applied in the study is critical to avoid misunderstandings. Therefore, the following terms are defined as follows:

- i. **Academic libraries-** libraries that are affiliated with higher education institutions, such as colleges and universities. These libraries serve the dual purpose of supporting the academic curriculum and research activities of the faculty and students within the institution (Budd, 1998).
- ii. **Artificial intelligence-** the simulation of human intelligence processes by machines, especially computer systems. Specific applications of AI include expert systems, natural language processing, speech recognition, and machine vision (McCarthy, 2004)
- iii. **Big data-** refers to the effective storage, management, retrieval, and evaluation of a large number of data sets in various formats requiring very fast internet connections (Rafael, 2019) and software to organise and process due to its unpredictability and unstructured nature (Wang, 2017).
- iv. **Fourth Industry Revolution (4IR)-**the Fourth Industry Revolution (4IR) has been defined as the onset of a technological revolution that is blurring the lines between physical, digital, and biological spheres (Schwab, 2015).
- v. **Internet of Things-** the Internet of Things, in simple terms, is the interconnection of physical devices with unique identifiers or Internet protocol addresses to collect and share data with little or no human intervention (Ranger, 2020).
- vi. **Virtual reality-** is computer generated simulations of images or whole environments to mimic natural realities and experiences through digital technology. Libraries are embracing virtual reality technologies to enhance their services by, for example, allowing virtual interaction rather than visiting the physical library (Oyelude, 2018).

1.10 Summary of Chapter One

The Chapter introduced the study on the effects of the 4IR on academic library services. It provided background information on how 4IR was characterised by the integration of advanced technologies such as artificial intelligence, big data analytics, and automation, which

transformed various sectors, including libraries. The discussion highlighted how academic libraries shifted from traditional methods to digital platforms, electronic resources, and automated systems to meet the changing demands of users. Additionally, the chapter outlined how these technological advancements presented both opportunities and challenges, requiring academic librarians to acquire new skills and competencies to remain relevant in the evolving information landscape.

The Chapter also presented the research problem, emphasising that while there was extensive global literature on the impact of 4IR on library services, there was limited research specifically focused on Zambia. The study aimed to bridge this knowledge gap by assessing how academic libraries in Lusaka Province adapted to 4IR-driven changes. Furthermore, the chapter highlighted the purpose of the study, which was to examine the extent to which emerging technologies influenced library operations, service delivery, and user experience. It also set out key research objectives and questions that guided the study in exploring the challenges and opportunities posed by 4IR in academic libraries.

Lastly, the significance of the study was discussed, highlighting its potential contributions to librarians, policymakers, and researchers. The findings were expected to provide insights into improving digital literacy, integrating emerging technologies, and addressing skill gaps among librarians. The chapter also outlined the study's scope, focusing on academic libraries in Lusaka Province while excluding public and special libraries due to their different operational contexts. By defining key concepts, the chapter laid the foundation for the study, ensuring a structured approach to investigating the transformative effects of 4IR on library services.

CHAPTER TWO: LITERATURE REVIEW

2.0 Overview

This chapter reviewed the literature on the effect of the 4IR on academic library services, as well as other relevant literature on the subject of study. The literature review was guided by the following sub-themes: Concepts of industrial revolution technologies, the extent to which Libraries have adopted the Fourth Industrial Revolution technologies within their library services, how the Fourth Industrial Revolution has influenced information access and retrieval methods in libraries, such as the adoption of online databases, and digital repositories, the skills and training requirements of library staff in response to the Fourth Industrial Revolution, and the challenges faced by libraries in adopting the Fourth Industrial Revolution technologies in their library services. The sources of information in the literature review included journal articles both open and closed access, reports from education organisations, books, and recommended readings from the supervisor among others.

2.1 Concepts of Industrial Revolution Technologies

According to Asemi and Asemi (2018), the Industrial Revolution is simply an era that introduced and developed technologies that are connected to digital transformation. Technology advancement has resulted in three global revolutions and a fourth is currently underway which all have impacted the practices and operations in libraries (Tella, 2022). Libraries in the world are gradually been transformed from traditional models to modern ones such as building bibliographic databases and supporting searching information.

Chidiebere (2023) opined that the revolution in the application of technologies in libraries is more of modern tools such as the application of library management software. The information and library industry has also entered the era of the 4IR with the development based on three main pillars namely, digital, biological technology, and physics. In particular, digital development is based on the core elements like Artificial Intelligence (AI), the Internet of Things, (IoT), and Big Data (Big Data) that are directly related to the information and library section. This is believed to bring a huge change in the provision of information to users (Cao, Wu, and Stvilia, 2020).

2.1.1 First Industrial Revolution

The 1IR, which began in the late 18th century and lasted into the early 19th, was a watershed moment in human history (Schwab, 2010). It was distinguished by a shift from rural and handicraft-based economies to industrialised economies propelled by mechanisation and technical advances. This transformational time laid the groundwork for modern industrial civilisation, influencing how products were manufactured, disseminated, and consumed.

One of the key catalysts of the IIR was the invention and widespread adoption of steam power. According to James (2020), the improvements to the steam engine in the 1760s and 1770s greatly enhanced its efficiency and reliability, making it a viable source of power for industrial machinery. Mokyr (1990), postulates that steam power revolutionised manufacturing processes by providing a reliable and consistent source of energy, enabling factories to operate on a much larger scale than ever before. This innovation spurred the development of textile mills, ironworks, and other industrial enterprises, laying the groundwork for the factory system.

Bambe (2019) on the other hand, revealed that the mechanisation of textile production was another hallmark of the 1IR. The invention of the spinning jenny by James Hargreaves in 1764 and the spinning mule by Samuel in 1779 revolutionised the textile industry by automating the spinning process (Nuvolari, 2021). These advancements significantly increased the speed and efficiency of textile production, leading to a surge in output and lowering costs. As noted by Aspin (1993), the mechanisation of textile production played a pivotal role in driving economic growth during this period, creating new job opportunities in urban areas and fuelling urbanisation.

The creation of new transport infrastructure also played an important part in facilitating industrialisation (Friedrich et al, 2022). Canals, and later railways, changed the transportation of goods and people by connecting industrial centres to raw material sources and increasing markets. According to Nuvolari (2021), the introduction of railways in particular had a significant impact on economic development, allowing for faster and cheaper movement of commodities across great distances. This not only increased trade and commerce, but also aided the integration of regional economies into a national market. The 1IR saw the establishment of several research universities. According to Hussain (2019), libraries grew in size throughout the 1IR, but due to uncontrolled growth, library administration became poor, and purchase funds were sometimes insufficient. As a result, services will be virtually non-existent. The librarians' employment was deemed part-time, and cataloguing lacked suitable methods.

2.1.2 Second Industrial Revolution

The 2IR, which lasted from the late nineteenth to early twentieth centuries, saw a substantial shift in industrial processes and technological breakthroughs (Lase, 2019). This age saw tremendous breakthroughs in a variety of industries, including manufacturing, transportation, and communication. One of the fundamental drivers of this revolution was the increasing use of electricity as a primary source of power, which replaced previous techniques such as steam. According to Filip (2014), the rise of the electrical power industry was the single most important factor in late nineteenth- and early twentieth-century industrialisation. The use of electricity transformed production processes, increasing efficiency and productivity.

The 2IR witnessed the birth of mass production techniques, most notably Henry Ford's assembly line system (Tomac, Radonja and Bonato, 2019). Ford's unique approach to automobile manufacturing significantly cut production costs, making vehicles more affordable to the general public. This transition not only revolutionised the automotive industry, but also served as a model for efficiency in a variety of other industries. As Hall (2004), points out, Ford's moving assembly line became the most significant manufacturing breakthrough of the twentieth century. The assembly line system streamlined production, allowing large-scale goods to be manufactured quickly.

In addition to advancements in manufacturing, the 2IR witnessed significant progress in transportation infrastructure. The construction of railroads expanded networks across continents, facilitating the movement of goods and people at unprecedented speeds (Lase, 2019). Railways played a pivotal role in connecting distant regions, fostering trade, and stimulating economic growth. According to Filip (2014), railroad construction was a major stimulus to the American economy during the 2IR, providing the infrastructure necessary for industrial expansion. The expansion of railroads spurred urbanisation and contributed to the rise of industrial cities.

Yudipratomo, City and Irwansyah (2020), asserts that the 2IR saw remarkable developments in communication technologies, particularly the invention of the telephone and the telegraph. These innovations revolutionised long-distance communication, enabling real-time transmission of information across vast distances. The telephone, patented by Alexander in 1876, transformed interpersonal communication and facilitated business transactions (Bambe, 2019). Similarly, the telegraph, which had been in use since the mid-19th century, experienced widespread adoption and played a crucial role in global communication networks. As De Jong

(2019) observes, the telegraph was the first technology to allow instant, long-distance communication, laying the groundwork for subsequent advancements in telecommunications

In the education sector, it brought about new powerful technologies that produce a large crop of new innovative educational institutions. This era was intended to enable industrial classes and open up opportunities for education to be accessible to all as students. Under this revolution, the Public Libraries Act of 1850 allowed England and Wales to establish public libraries during this revolution (Sharma, 2019). Hussain (2019) asserts that prior to Queen Victoria's Golden Jubilee in 1887, the construction of libraries was relatively limited. However, the 1880s and 1890s saw the establishment of numerous small and medium-sized libraries. By 1914, 62% of the population resided within areas governed by library authorities. During the 2IR, book collections expanded and became more accessible to readers.

2.1.3 Third Industrial Revolution

The 3IR began in the 1950s leading to the invention of computers and the Internet. This period brought in automation and robotics (Tantawi et al. 2019). The 3IR brought education to an environment where access to information was immediate and free, shifting focus towards active learning pedagogies that placed a premium on collaboration within diverse teams and peer learning environments (Mazur, 2019). The library data storage problem was solved in this revolution. Machine Readable Cataloguing took place in 1966 and got more advancement in this revolution (Hussain, 2019).

To oversee the library automation planning, selection, and implementation, libraries began to establish offices directly. Due to the technological complexity of the automation process, the sophistication was considered a tool for experiments. Automation became easier to work with for the professionals and users. Vaidya and Bhosle (2018) added that inter-library loan and online database searching also started in this revolution. Libraries became more decentralised due to automation factors. Resource sharing was adopted due to the continued lack of funding and space for material. Reference services have become a serious topic and more sophisticated because of highly specialised information. The inter-library loan became more cross-accessible via accessing services at national and international levels to fulfil the needs of society.

2.1.4 Fourth Industrial Revolution

The 4IR also known as industry 4.0 is defined as the bringing together of economies, scale and economies of scope to produce new technologies, which will in turn adopt the use of computers, Internet of Things (IoTs) and cloud computing to monitor production processes (Penprase, 2018). The Fourth Industrial Revolution (4IR) is transforming the way people live, work, and communicate, significantly impacting various industries, including libraries. According to Hussain (2019), the 4IR is largely driven by data and the Internet, both of which play a crucial role in guiding how we collect and manage the ever-expanding volume of information. This world is fuelled by data and internet-connected devices that are capable of collecting and processing huge amounts of data. Social media, smartphones, digital cameras, and sensors are creating more information than ever before. The flow of information is increasing at an alarming rate. People and machines are connecting at enormous speed and data is being collected and harnessed like never before.

Artificial intelligence (AI), Mobile computing (MC), Machine learning (ML), and automation of every trade have become a need of the day. Many people believe that these changes are scarce (Hussain, 2019). Some libraries use robots in combination with Radio Frequency Identification (RFID) technologies. Bibliographic records can be retrieved from storage, allowing books to be shared with users upon request. In the era of the Fourth Industrial Revolution (4IR), technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) play a crucial role in managing library data. These innovations enable library professionals to identify critical errors and enhance the presentation of bibliographic information on the web.

Ocholla and Ocholla (2019), who researched the changing library and information research scene in South Africa, discovered that staff are particularly interested in new technology to assist library services. Aslam (2019) conducted a study on the effectiveness of leadership styles among academic research librarians in Eastern and Southern Africa, and discovered that librarians advocate new technology adoption to make the library appear clever. Similarly, Onyancha (2018) and Raju (2017) found that librarians will willing to encourage innovation in the form of leveraging smart technologies to revolutionise the delivery of library services.

2.2 Adoption of the Fourth Industrial Revolution Technologies within Library Services

All over the globe, libraries have been acknowledged as institutions that provide the information needs of individuals who require specific pieces of information for their

occupational, educational, and personal development. Libraries are dedicated to providing free and equitable access to information for students both in written, electronic or audio-visual form (Asim et al. (2023). The 4IR has resulted in substantial changes in information technology, altering a variety of industries, including education and library services (David-West, 2021).

2.2.1 Integration of Artificial Intelligence

A study done by Sony and Naik (2020), revealed that AI holds immense potential for revolutionising library services. Libraries are leveraging artificial intelligence powered chatbots for virtual reference services, enhancing user interactions, and providing real-time assistance. Moreover, artificial intelligence (AI) algorithms are employed for data mining and analysis, enabling libraries to extract valuable insights from vast collections and optimise resource allocation (Brown and Lopez, 2019). Vysakh and Rajendra (2020) conducted a study on the integration of artificial intelligence in libraries, and their study revealed that libraries can integrate robotics with other artificial intelligence technologies like a drone being controlled by a robot that can make sure that the libraries are always under surveillance were robots can be placed in various sections of the library as a user aid and guide. While the study for Vysakh and Rajendra focused on general applications of robotics, the effect on academic libraries' services, and the overall library environment in the context of the 4IR was underexplored, particularly in developing countries. Hence, this study presented an opportunity to assess the practical challenges and benefits of 4IR in academic libraries.

Xing and Marwala (2017) stated that the 4IR represents a complicated, dialectical, and exciting opportunity for higher education that can reshape society for the better. They warn that AI may shift the workplace from task-based to human-centered features. This may lessen the gap between the humanities and social sciences, as well as science and technology, resulting in a greater demand for interdisciplinary teaching, research, and innovation. The new environment is expected to include virtual classrooms and laboratories, virtual libraries, and virtual teachers. Brown and Lopez (2019) determined that the 4IR would improve, not harm, the educational experience. Sanji, (2022) looked at the application of artificial intelligence (AI) and chatbots in libraries. Sanji also states that, these technologies can help libraries provide personalised services to students and researchers, enhance efficiency, and minimise staff workload.

Asim et al. (2023) did research on the use of AI in Pakistani university libraries with a sample size of 237 university librarians. Their findings revealed that Pakistani university libraries are using limited AI-based library services, including text-to-speech and speech-to-text

technologies; Google Assistant to search by voice command; Radio Frequency Identification (RFID) systems for self-checkout, check-in, and security purposes; and intelligent data analysis for collection management. It is obvious that many knowledge management experts in Pakistani universities are aware and eager to adapt to the world dominated by artificial intelligence (AI); this can be noted by their willingness to integrate artificial intelligence (AI) systems meet the demands of users through user feedback as well as their association with AI experts and other professionals. This finding is in line with the later work of Lukasz (2022) who found that South Africa has adopted a lot of disruptive technologies be it robotic, cloud computing, AI, big data, Blockchain, and others to boost the growth of its economy.

While the study by Asim et al. highlighted the use of specific AI-driven services in Pakistani university libraries, such as text-to-speech, voice-activated searches, RFID systems, and data analysis, the assessment academic libraries in Zambia may reveal differing levels of AI implementation, infrastructure, and awareness. This could also encompass the extent to which libraries are leveraging AI to transform library services and align with the broader technological shifts of the 4IR, especially considering regional challenges and resource availability.

Similarly, Harisanty et al (2022) conducted artificial intelligence (AI) awareness research in libraries with significant persons in Indonesia, including scientists, leaders, and practitioners. Their study adopted a purposive sampling technique to select the 38 participants. The study discovered that the majority were completely aware of AI systems in libraries and had a positive attitude towards AI integration in libraries. The aforementioned research show that most information experts are aware of AI and its integration into libraries. These findings may entail keeping up with technology advancements to meet customers' information needs, embrace change, and increase employment capacity.

The gap between the findings of Harisanty et al and assessment of the an effect of the Fourth Industrial Revolution (4IR) on library services lies in the contextual differences and the focus of each study. While Harisanty et al. found that most library professionals in Indonesia were aware of AI and had a positive attitude towards its integration, their study did not specifically address the broader implications of 4IR on library services, such as automation, data analytics, or the changing role of libraries in education and research. An assessment in Zambia would need to explore the actual implementation of 4IR technologies in academic libraries, the challenges faced by libraries in adapting to these changes, and the readiness of library staff and

infrastructure to integrate new technologies, which may differ from the Indonesian context in terms of resources and technological advancements.

Yu (2019) asserted that the world is steadily becoming an intelligent society as a result of the widespread application of artificial intelligence technologies, which is dramatically changing the nature of library services and developing smart libraries for easier, faster, and more convenient information access and retrieval. The survey also discovered that certain libraries have used AI apps as part of their security system. Face recognition, rather than library identity cards, is utilised to allow access to the actual library. Vijayakumar and Sheshadri (2019) found that the use of artificial intelligence in libraries is an innovation that allows librarians, users, and machines to interact to address information demands. A typical example is searching engines' capacity to correct spelling and provide additional relevant material when doing information searches.

The findings by Yu and Vijayakumar and Sheshadri highlighted global advancements in artificial intelligence (AI) applications in library services, such as facial recognition for access and intelligent search tools. However, a gap existed in understanding how these 4IR technologies were being adopted and affecting library services in specific regional contexts like Zambia. While global studies demonstrated the potential of AI to transform libraries, there was limited empirical evidence on the extent, challenges, and impact of such innovations in academic libraries in Zambia, thereby necessitating localised research to assess their readiness, implementation, and outcomes.

Momodu (2015), citing Oyegunle (2013), posited that the adoption of artificial intelligence applications has helped university libraries to mitigate threats of other retrieval systems and provide services that surpass that of Google search. Liu (2010) provided an almost exhaustive literature review on the utilisation of AI and robotics to enhance the quality of services in the university library. The activities include automated indexing and abstracting, expert system reference services, cataloguing, and classification. Whitehair (2016) also noted that AI also gives a competitive edge and a method for libraries to deliver better service to their clients in the current information age. The use of AI to reach and entice potential customers with high reading skills provides opportunities for advanced service offering and user experiences. The quick, concrete, and proven ability to provide actual, immediate advantages to library workers and consumers distinguishes AI applications in libraries.

Even though, these studies focused largely on the technical and service-oriented benefits of AI, they do not sufficiently address how the integration of 4IR technologies beyond AI alone is reshaping library operations, user engagement, and strategic planning in a developing country context like Zambia. This gap necessitates a localised assessment to understand both opportunities and challenges unique to academic libraries in Zambia amidst the 4IR wave.

Starting with the digitalisation of information materials and the application of the Internet of Things (IoT), analysis of Big Data and intelligent machine learning, as well as innovations, have reshaped the way people seek, absorb, connect, and disseminate information, as well as their ability to use the information, make sense of it, and, eventually, make informed decisions based on it (Bansode, and Shinde, 2019). Libraries can take advantage of the available practical benefits of artificial intelligence for their own goals, such as improving processes, increasing organisational efficiency, and generating new library information services.

De Sarkar (2023) asserts that artificial intelligence will transform the way various information services operations are carried out. An AI online assistant may seamlessly link with library applications and systems and aid information users with their search, discovery, and retrieval processes. Artificial intelligence systems can be used to retrieve important data from a large group of materials, including information-rich graphical resources like maps, and produce an overview to aid study. Chatbots can be used as an aspect of librarian reference activities or readers' advisory services (Oyegunle, 2013). Automated AI applications can help with tasks like cataloguing, indexing, and abstracting that are currently completed by trained professionals. As a result, librarians must keep an eye on the developments in AI technology and proceed with caution understand how they influence users' information needs, information-seeking patterns, learning, and teaching activities, and how typical library services and operations are currently carried out.

Although, these studies have emphasised the potential of AI to improve library functions, there was lack of localised research examining how these technologies were being adopted or experienced within academic libraries. This resulted in a knowledge gap regarding the preparedness, challenges, and real effect of 4IR technologies on library operations, user behaviour, and service delivery in the context of Zambian academic institutions.

Mali and Deshmukh (2021) did a study on the applications of Artificial Intelligence in Library in India and their study discovered that AI affects both library technical and reader services. In technical services, it improves the maintenance and development of library collection metadata,

user data, and library information resource usage statistics by utilising AI tools such as Big Data and Text Data Mining. Natural language processing, pattern recognition, chatbots, and robotics are examples of AI techniques that have been gradually used in reader services and information retrieval. While the studies for Mali and Deshmukh provided a technology-specific analysis within a national context, the Zambian assessment required a broader exploration of 4IR technologies including AI, IoT, automation, and cloud computing and their collective effect on infrastructure, policy, skills development, and service delivery in a localised academic setting. This gap underscores the need to contextualise global technological trends within regional realities and institutional capacities.

Joudrey and Taylor (2018), conducted on how AI is been used in the library for cataloguing and the study revealed that AI is increasingly being utilised in libraries to enhance cataloguing and classification processes, thereby improving efficiency and accuracy. AI-powered tools such as machine learning algorithms and natural language processing enable automated metadata generation, subject classification, and semantic search capabilities, reducing the manual workload for librarians. Furthermore, AI can analyse large volumes of bibliographic data, identify patterns, and suggest classifications based on existing taxonomies, ensuring consistency in cataloguing practices (Srinivasan, 2021). Such advancements not only streamline library operations but also enhance user experience by providing more precise search results and personalised recommendations.

The gap between the findings of Joudrey and Taylor and the current study lies in the contextual and practical application of AI technologies. While Joudrey and Taylor focused broadly on the capabilities and benefits of AI in enhancing cataloguing processes, they do not address the specific challenges, readiness, infrastructure, and adoption levels in developing countries like Zambia. The local assessment would need to explore how 4IR technologies, including AI, are actually impacting library services in this specific context considering factors such as digital literacy, funding, policy frameworks, and institutional support which may significantly differ from those in more technologically advanced settings.

Ajakaye, (2021) investigated the application of AI techniques in a digital video collection in Nigeria. The study intended to automate metadata creation to support the library's interface and make it more user friendly. The project uses speech recognition, natural language processing, and picture analysis to provide AI-based interface components like video skims, representative frames, and word position tagging. These AI algorithms create a user interface for the digital

video collection, allowing users to rapidly find and obtain relevant information. While each of the AI algorithms used has flaws, the authors point out that they are nevertheless successful in developing powerful navigation tools for the digital video library.

The gap between the current study and Ajakaye's scope and focus lay in the research's scope and focus. Ajakaye specifically examined the application of AI to enhance digital video collections in a Nigerian library. In contrast, a broader assessment of the Fourth Industrial Revolution (4IR) in Zambian academic libraries encompassed a wider range of emerging technologies, such as robotics, the Internet of Things (IoT), and big data and their systemic impact on library services, operations, and user engagement. Moreover, Ajakaye's work was technology-driven and tool-specific. In contrast, a 4IR assessment adopted a more holistic approach, addressing infrastructural readiness, policy frameworks, staff competencies, and user adaptation within the academic library context.

Subaveerapandiyan (2024) conducted a workshop on AI in Digital Libraries as part of the International Joint Conference on Artificial Intelligence (IJCAI) in India and the research methodology involved utilising the Scopus database and identifying 66 relevant articles related to AI. The workshop explored how AI techniques could address challenges in building digital libraries. The major submissions explored AI-driven information discovery and retrieval, leveraging natural language processing (NLP) and machine learning to enhance search accuracy and relevance. Preference logic was utilised to personalise recommendations, improving user experience. Multi-agent systems were proposed for automating classification and indexing, optimising cataloguing efficiency. The findings from Subaveerapandiyan primarily focused on the potential of AI technologies such as NLP, machine learning, and multi-agent systems in enhancing digital library functions like search, recommendation, and cataloguing. In contrast, the current study would explore broader systemic transformations, including infrastructure readiness, policy adaptation, staff digital skills, and user access challenges.

Moustapha and Yusuf (2023), assessed the application of artificial intelligence and technological innovations in the provision of library services, specifically the types of AI that could be used in academic libraries. According to the article, the University of Calabar already uses Robots and Chabot to manage some of its service demands. Nawaz and Saldeen examined the use of AI in library reference services (2020). The study's findings suggested that Chabot may be utilised to efficiently deliver library reference services. Oname and Alex-Nmecha

(2020) conducted research on AI applications in libraries. The study emphasised the use of expert systems in shelf reading, book reading robots, and library reference services, among other applications.

The existing studies by Moustapha et al focused primarily on the specific applications of artificial intelligence such as chatbots, robots, and expert systems in enhancing library services, particularly in reference assistance and operational tasks. However, these studies did not comprehensively address the broader effect of 4IR on library services, especially within the unique socio-economic and infrastructural context of academic libraries in Zambia. The gap, therefore, lies in the need to assess how 4IR technologies as a whole not just AI are influencing service delivery, staff roles, user experiences, and institutional readiness in Zambian academic libraries.

Yu (2019) investigated how smart libraries use AI in Shanghai University of Medicine and Health Sciences. The paper mentions several artificial intelligence applications that can be used in smart libraries, such as face recognition, chatbots, and self-service AIs. Ali et al. (2020) investigated how university librarians perceived and used AI tools in Pakistani. According to the report, university libraries might use the following AIs: Google Chat for chat reference, Google Drive, Drive One, cloud computing for big data, RFID, 3M Gates, thumb verification, and Google Translator for translation services, among others. Subaveerapandiyan (2023) investigated the potential for artificial intelligence to improve library operations and services. Researchers will be able to show through their investigation that robots help provide library services. Vysakh and Babu (2020) looked at robotic AI deployment in libraries. The findings indicated that most jobs carried out in libraries can be done by robots such as taking the inventory of the library which uses RFID and barcode technology.

Nawaz and Saldeen (2020) investigated AI solutions for library resources and services during the COVID-19 outbreak at Kingdom University in Bahrain. The research shows that a variety of library services can benefit from the usage of AI. Nonetheless, AI can be used for user identification in speech recognition or typing, monitoring of users' use of library resources and services, chatbots for reference services, robot assistants, drone surveillance for library security, AI alarms to remind users when it's time for their scheduled appointment with a librarian, and AI-based tutorials to keep users up to date on the most recent findings and discoveries in their field. The AI revolution in libraries is projected to have a significant impact

on a number of areas, including data processing, literacy, and online and virtual services (Winkler and Kiszl, 2021).

A study done by Tella and Ajani (2019), has shown that humanoid robots can be used in libraries for a variety of tasks, including instruction, community building, and assistance for librarians in Nigeria and their study adopted conceptual analysis and review of literature on AI humanoid robots for public libraries reference services. Other applications for AI in libraries include chat services for online messaging, automation of library procedures, and improving the effectiveness of service delivery (Ajakaye, 2021). A study on intelligent talking robots to improve library services was conducted by Yao et al. (2015). The results make it clear that the Xiaotu robot, which can interact with users and provide assistance, is effective in enhancing library reference services.

While studies by Tella et al highlighted the potential and implementation of AI and humanoid robots in enhancing library services, they focused primarily on other geographic contexts such as Nigeria and China. There is limited empirical evidence on how 4IR technologies are being adopted, adapted, or resisted within academic libraries in Zambia. This gap underscores the need for localised research to assess the readiness, challenges, and effect of 4IR innovations on library operations, service delivery, and user engagement in the Zambian academic context.

Subaveerapandiyan (2023) in their study argued that artificial intelligence may be applied in a variety of library operations areas, freeing librarians from some boring tasks such as cataloguing, classification, reference Services and circulation management. Corrado, (2021) stated that AI can be used in a variety of technical service domains, including assigning and developing subject headers, classification, and metadata description. Librarians would act as supervisors and ensure metadata ethics and privacy in these apps. Mogali (2015), investigated how artificial intelligence is applied in libraries in India. The findings show that artificial intelligence may be applied to expert systems in libraries, including Ref-search, pointers, online reference aid, Amswerman, and Plexus.

Yusuf et al. (2020) examined the usefulness of AI in providing library services in a survey of Nigerian university libraries and their study employed a qualitative approach, utilising a case study design to capture the perspectives of reference librarians in the north-central geopolitical zone of Nigeria. Data was collected through semi-structured interviews with 52 reference librarians. The study demonstrated that the adoption of AI by librarians in Nigerian university libraries, notably in Kwara State, is low due to a number of constraints unique to poor

countries. However, as noted by Grant and Camp (2018), many academic libraries in industrialised countries, have embraced AI to meet their customers' broad reader service demands, including circulation, serials, and reference services.

The study Yusuf et al. highlighted the limited adoption of AI in Nigerian university libraries due to infrastructural and economic challenges, particularly in Kwara State. The current study focused on Zambia on how 4IR technologies beyond just AI are shaping library services in a different socio-economic and technological landscape. This included examining the integration of automation, big data, and digital platforms in Zambian academic libraries and how these innovations are influencing access, efficiency, and user experience, thereby offering a broader and potentially more advanced perspective on technological adoption in libraries

In another study, Quyet et al. (2023) evaluated a unique AI framework for library operations in preparation for the digital revolution of higher education in Vietnamese. The current body of research indicates that university libraries have a low acceptance rate for using AI to provide innovative alternatives to the services they currently provide. Practically in every field of academic and research libraries today, according to Moustapha and Yusuf (2023), technology is being used, and Nigeria is not being left behind because the acceptance and application of technology in Nigeria is not a modern concept

Omame, and Alex-Nmecha (2020) looked at AI technology for library resources and services in Nigeria. According to their study, the use of artificial intelligence can improve several library services. However, AI can be utilised for user authentication through speech or typing recognition, monitoring users as they use library resources and services, chatbots for reference services, bot assistants, monitoring drones for library security, and AI alerts to remind users when it's their turn. Users can keep up to date on the newest breakthroughs in their profession by scheduling sessions with a librarian and using AI-based courses. The AI revolution in libraries is projected to have a considerable impact on several sectors, including data processing, literacy, and online and virtual services (Winkler and Kiszl, 202).

2.2.2 Utilisation of Big Data Analytics

In recent years, libraries have increasingly used big data analytics to improve their services and operations by harnessing massive amounts of digital data created by library systems, user interactions, and other sources (Wang and Xu, 2017). One important use of big data analytics in libraries is the examination of consumption trends to optimise collection development

strategies. Libraries can discover patron trends and preferences by tracking characteristics like as item circulation, database usage, and interlibrary loan requests, allowing them to make educated resource purchase and deselection decisions (Parbe et al. 2021).

Ball (2019), conducted a study on Big Data usage in libraries, which found that it has a favourable impact on how digital information and communication are managed in Switzerland. It also enables them to examine and synthesise vast volumes of data in order to have a comprehensive picture of their user base's statistics, allowing them to update and improve their environment and services. It improves scholarly work, resulting in cost savings, automation, and faster, more accurate conclusions (Blummer and Kenton, 2018). While Ball's study focused on Big Data's role in enhancing digital communication, user data analysis, and operational efficiencies in Switzerland, there is limited exploration of how these advancements translate into the unique context of academic libraries in Zambia.

Big data analytics is essential for enhancing libraries' operational effectiveness and resource allocation. According to a study by Parbe et al. (2021), libraries may maximise their human and physical resources to better serve their patrons by accessing data on staffing levels, facility usage, and resource availability. To improve the overall user experience, libraries can distribute resources more effectively by using analytics to determine peak usage hours for study rooms or high-demand products (Sahid, and Sani, (2021). In addition to increasing the efficiency of library operations, this data-driven strategy makes sure that resources are distributed in a way that maximises their influence on scholarly research, teaching, and learning.

Subhajit (2019) investigated how big data is used in academic libraries in India and the study discovered that only 15% of institutions have been able to integrate it into their daily operations, even though, big data analysis can reveal patterns, trends, and associations in extremely large data sets, particularly when it comes to human behaviour and interactions. The reasons provided for the low utilisation will a lack of competent workers, confusing laws, and data protection concerns (ibid). The author came to the conclusion that librarians don't necessarily need to be programmers, but they should at least possess the essential knowledge, abilities, and customer-focused mind-set required to use a range of software tools to transform vast volumes of data.

2.2.3 Integration of Internet of Things

Academic libraries can improve user experiences and operational efficiency by utilising the Internet of Things (IoT). Real-time monitoring of library resources, environmental conditions, and space utilisation is made possible by the Internet of Things through sensors and devices (Zhang et al., 2019). According to Singh and Mahajan (2014), radio frequency identification, or RFID, is a subset of the Internet of Things that is extensively used in university libraries for self-checkout systems, security, and inventory management. The user experience can be improved overall, resource allocation can be improved, and library layouts can be optimised with the help of the Internet of Things (IoT).

Tan and Luyt (2017) revealed that Internet of Things devices can be used to construct smart library environments that respond to users' requirements in real time in India. For example, sensors embedded in furniture and study areas can collect data on space utilisation, temperature, and noise levels, allowing librarians to optimise library layout and improve patron comfort (Yin et al., 2018). These data-driven insights allow libraries to create more hospitable spaces for studying and collaboration, increasing overall user happiness and engagement with library resources.

Khan (2021) did a study on enhancing operational efficiency and user experience with the Internet of Things (IoT) in India. The study found that technologies allow libraries to provide novel services such as personalised suggestions and context-aware support. Libraries can employ the Internet of Things (IoT), data analytics, and machine learning algorithms to assess users' preferences, borrowing histories, and study habits and provide tailored suggestions for relevant resources and services. Furthermore, the Internet of Things will allow virtual assistants or chatbots to provide real-time assistance to library patrons by answering questions, directing navigation, and providing proactive support based on users' whereabouts within the library (Venugopal and Somanadh, 2024). While the study by Khan's highlighted the use of IoT, data analytics, and machine learning to personalise services in Indian libraries, the study current study may in Zambia may focus more on the broader effect of the 4IR considering regional challenges, such as technological infrastructure, user acceptance, and the availability of skilled personnel, which could influence the adoption and EFFECT of such

Wojick (2016) did a study on Internet of Things potential for libraries in India and the study concluded that IoT enables library clientele to utilize available information resources with ease as it provides innovative ways for sharing information, tracking, tracing services, and

notification services, while Liang (2018) added that it controls and tracks the movement of library resources and reduces the workloads of the librarians. Liang (2018), Liu and Sheng (2017) as well as Pujar and Satyanarayana, (2015), alluded to IoT enabling digitized security systems to prevent theft of library resources and alert the emergence of security personnel. While the aforementioned studies focused on IoT's role in improving operational efficiency, security, and resource tracking, an assessment of 4IR in Zambia considered the integration of other advanced technologies like artificial intelligence, machine learning, and big data analytics.

Studies conducted by Kaba and Ramaiah (2019) and Nolin and Olson (2016) revealed the remarkable function of IoT at library circulation desks in United States of America. Applications for informing or warning users about the availability of library resources, overdue books, profiles, and circulation policies and guidelines are provided by it. In addition, it enables interlibrary loans, user identification, book shelf location, online library material reservations, and fire detection. Thus, the Internet of Things enhances access to resources and collections while saving time and effort for both library personnel and patrons.

The integration of Internet of Things in libraries presents serious concerns about data privacy, security, and ethical usage. To protect sensitive data collected by Internet of Things devices, libraries must develop strong security measures and privacy policies to prevent breaches and unauthorised access (Ram, 2023). Ram also discovered that librarians must maintain open communication with users on the collection and use of Internet of Things (IoT) generated data, while preserving individuals' rights to privacy and informed consent. By proactively addressing these difficulties, libraries may exploit the revolutionary potential of Internet of Things (IoT) technology while maintaining standards of data ethics and privacy protection. For example, Schwab (2016) proposed that the 4IR provides both promise and hazard to humanity; so, it is prudent to foresee what is unknown and proactively prepare arrangements before the changes inevitably happen.

2.2.4 Implementation of Blockchain Technology

Blockchain technology is gradually making its way into different areas, including libraries, to address long-standing concerns such as data integrity, authentication, and transparency (Atkinson, 2018). Implementing blockchain in libraries has the potential to transform existing library management systems by providing a decentralised and secure platform for managing resources, transactions, and intellectual property rights. According to Usman and Ullah (2024),

blockchain technology can improve the trustworthiness of libraries by ensuring the immutability of records, reducing concerns about data tampering and manipulation.

According to Ameer (2020), blockchain is a new and dependable technology that aids in the security, preservation, and reliability of information; hence, it can be extremely valuable for libraries and librarians in providing effective service to their users in this century. Ameer also added that blockchain technology can be used to overcome several issues in the field of libraries when properly implemented for information storage in a distributed setting that cannot be manipulated by unauthorised users. Librarians must be well-versed in the potentials and capabilities of blockchain technology in order to apply it effectively for service delivery.

Tang and Chen (2020) did a study on blockchain in libraries, which found that one of the most important applications of blockchain in libraries is the administration of digital assets such as scholarly publications and research data in China. Academic libraries can use blockchain's distributed ledger technology to produce a transparent, tamper-proof record of digital asset ownership, usage rights, and credit. Riley-Huff, and Rholes (2011) also discussed how this can help with effective copyright administration, work attribution, and usage data tracking. Furthermore, blockchain-enabled smart contracts can automate licensing agreements and royalty payments by simplifying the process of accessing and using digital resources in the community.

The studies by Tang et al focused on blockchain applications in Chinese academic libraries and emphasise transparent digital asset management, copyright administration, and smart contracts, the current study assessed how emerging technologies, including blockchain, are being integrated into local academic libraries. This includes evaluating the readiness of these libraries for 4IR technologies, the specific challenges they face, and how these technologies, such as blockchain, could be adopted to improve services like resource management, data access, and intellectual property protection within the local context.

Another area where blockchain can have a significant impact is to improve the security and legitimacy of credentials and certificates. With the expansion of online education and the growing demand for remote qualification verification, blockchain-based credentialing systems provide a dependable option for confirming achievements without the use of middlemen. As Tang and Chen (2020) pointed out, blockchain-based credentialing platforms can serve as a decentralised and tamper-proof repository for records, allowing individuals to securely

communicate their credentials with employers, educational institutions, and other relevant parties.

According to Patel (2021), blockchain technology can help institutions collaborate more easily by facilitating the safe and open sharing of financial information, research results, and resources. Libraries can facilitate interdisciplinary collaboration, expedite the transmission of knowledge, and support open research projects by developing decentralized networks driven by blockchain technology. This is consistent with the idea that blockchain technology might act as a catalyst to democratize and decentralize knowledge, as emphasized by Gundakanal (2023). All things considered, the incorporation of blockchain technology into libraries has enormous potential to revolutionize the digital age's methods of managing, sharing, and gaining access to knowledge. This will open the door to more open, effective, and inclusive scholarly communication ecosystems.

Suman and Patel's (2021) did a study that looked at Blockchain technology and its application in libraries at Mahatma Gandhi Central University in India. The findings show that blockchain technologies help secure authors' intellectual property and copyrighted content while also supporting publishing and Digital Rights Management. The report went on to say that in a developing country like India, implementing blockchain would be beneficial in bringing about significant improvements in library services. Similar findings were discovered in the study by Chen et al (2018), which stressed that blockchain plays spectacular roles in library services like digitization, preservation, and tracking of records, library card, library verification of credentials, and intellectual property (Hirsh and Kim, 2019). While the studies conducted by Suman et al. have examined the role of blockchain in intellectual property protection, digitization, and rights management, the broader integration of these technologies within the 4IR framework in Zambian academic libraries remains unexplored.

According to Habib and Sharma (2022), librarians must be knowledgeable of blockchain technology, particularly its potential, benefits, and hazards, in order to effectively apply it to library service delivery. Obim (2022) discovered that one of the greatest barriers to the widespread use of blockchain technology in libraries is a lack of awareness of the concept. This implies that librarians' awareness of blockchain is limited, which has an impact on its use for successful service delivery. Raising knowledge of developing technology is critical to its adoption and deployment in companies and institutions, including university libraries.

2.2.5 Adoption of Augmented Reality and Virtual Reality

Virtual reality has been around since the early 1960s, although it has only recently received substantial attention (Greene and Groenendyk, 2021). According to Johnson et al. (2016, p. 40), virtual reality is a "computer-generated environment that simulates the physical presence of people and objects to generate realistic sensory experiences." Virtual reality is often defined as an experience in which a person remains physically present in the real world while experiencing a virtual world via a headset and a computer or mobile device (Hahn, 2017). Internationally, libraries have made explicit efforts to make virtual reality available to their customers, as it may be utilized to engage technologically savvy patrons (Massis, 2015).

Frost et al. (2020) conducted a survey of Brigham Young University Library patrons to identify their interest in and needs for virtual reality technology at Brigham Young University in United States of America. The results suggested that there was adequate interest to expanding the present service. Customised library applications can be utilised for in-house activities such as storytelling, virtual travel, virtual gaming, and skill development, whereas the Aurasma mobile application may pique users' interest in exploring various library resources. The survey also stressed the utilisation of virtual reality to provide access to relevant library resources, as well as the foundation's ability to develop basic information literacy skills that allow them to assess, retrieve, and evaluate relevant material in order to accomplish work. Although the findings reflected that students showed interest in exploring virtual reality technologies, applying it in their various disciplines was challenging for students without engineering, medicine, or another related science background.

The study by Santos and Esposito-Betan (2017) on virtual reality at the College of Engineering Library at the University of the Philippines had similar findings. They concluded that virtual reality is advantageous to academic or research libraries offering library orientation programmes and information literacy initiatives. As such, virtual reality should not be viewed only as an application or technology, but rather as a gateway or a medium to relay relevant information to their clientele. A similar study by Huang et al. (2016) concluded that offering virtual reality library services is cost-effective, especially where large student groups are involved. In their literature review of virtual reality in education, Akcayır and Akcayır (2017) added the benefits of being user-friendly, as a user can easily follow instructional guides to download materials from mobile applications, as well as being interactive and fun to use. Utah

Stated University (2017) opined that virtual reality also allows students to view concepts in 3D, resulting in them visualising and grasping the information easier.

The gap between the findings of Santos et al. lies in the broader scope of technological transformation. While the studies focused on virtual reality as a specific tool enhancing library services, the assessment of 4IR encompassed a wider range of technological innovations such as AI, automation, and big data, along with their combined effects on academic libraries in Zambia. The gap lies in understanding how these diverse technologies, beyond just virtual reality, are impacting library services, infrastructure, and user engagement in the context of Zambian academic libraries.

Ocholla and Ocholla (2010) investigated the readiness of academic libraries in South Africa to support research, teaching, and learning in the 4IR. The survey found that South Africa has been actively in promoting the use of Lib 4.0 to improve teaching and learning. For example, the University of Pretoria and the University of South Africa have integrated Lib 4.0 3D technology, Makerspace, artificial intelligence, robots, and virtual reality into their library services. Ocholla and Ocholla (2020) analysed 26 South African academic library websites and concluded that academic libraries are responding with extraordinary ingenuity and originality to the revolution.

In recent times, augmented reality gained prominence as a technology capable of revolutionizing library services. By overlaying digital content onto the physical environment, augmented reality enhanced user interaction with library resources, offering new dimensions of engagement, learning, and exploration (Adewusi et al., 2024). According to De-Sarkar (2023), augmented reality was a technology that projected virtual objects or information onto the real-world environment, thereby enhancing the user's perception of reality. Distinct from virtual reality, which immersed the user in a completely digital environment, augmented reality integrated digital content with the physical world. This capability opened up a myriad of possibilities in the library service environment, making augmented reality one of the most promising emerging technologies in 21st-century librarianship.

Studies by Dalili et al. (2021) on augmented reality technology in the libraries of universities of medical sciences: identifying the application, advantages and challenges and presenting a model suggested that augmented reality technologies typically involved a combination of hardware and software components. Their study was qualitative study and the statistical population comprised 20 AR experts, and the data were collected based on in-depth semi-

structured interviews. Their study established that hardware included devices such as smartphones, tablets, smart glasses, and wearable sensors, while software consisted of applications designed to create and display augmented reality content. Key technologies enabling augmented reality included computer vision, Simultaneous Localization and Mapping (SLAM), and depth sensing (Kiradi et al., 2018).

According to Barman (2023), unlike virtual reality, which immersed users in a completely virtual environment, augmented reality enhanced the real-world environment by adding layers of digital content that users could interact with through augmented reality-enabled devices like smartphones, tablets, or augmented reality glasses. As observed by Dalili et al. (2021), the key components of augmented reality technology included computer vision with algorithms that enabled the recognition and tracking of physical objects and environments. There were also tracking mechanisms comprising sensors and GPS technology that provided spatial awareness and location-based augmented reality experiences. Additionally, the components included display devices with screens or lenses through which users viewed the augmented content, ranging from handheld devices to wearable augmented reality glasses. However, augmented reality applications typically relied on software platforms that integrated digital content with real-world imagery in real time, creating a seamless mixed-reality experience for users.

Singh and Rana (2022) maintained that the integration of augmented reality into library services opened up a wide range of innovative applications that enhanced user engagement, facilitated access to information, and transformed educational experiences. Agwuna, et al, (2024) asserted that augmented reality technology was used in information retrieval and navigation because it significantly improved how users navigated library spaces and accessed information resources. By connecting digital information to the library's physical environment, augmented reality-enabled devices provided users with effective real-time navigation guidance, interactive maps, and location-based information retrieval (Hafeez et al., 2024). Library users could easily locate specific books, resources, or services through visual cues and augmented markers displayed on their devices. For instance, augmented reality could guide users to the exact shelf location of a book based on their search query or provide directions to different sections of the library.

Hussain (2022) viewed augmented reality as technology that enhanced educational experiences within libraries by offering interactive and immersive learning tools. As such, libraries could use augmented reality to augment traditional learning materials with multimedia content, 3D

models, simulations, and interactive quizzes. For example, historical archives and rare manuscripts could be brought to life through augmented reality, allowing users to explore virtual reconstructions or digitally interact with historical artifacts. Kannegiser (2021) acknowledged that augmented reality facilitated virtual tours of library collections and exhibitions, providing contextual information and enriching the learning experience through multimedia presentations. It transformed library exhibitions and displays by adding dynamic and interactive elements that engaged visitors. While the studies by Hussain and Kannegiser highlighted the potential of AR to enhance library experiences globally, particularly through interactive tools and virtual tours, there is limited exploration of how such technologies are currently being utilised or assessed in Zambian academic libraries.

2.2.6 Cloud Computing

Cloud computing in libraries refers to the practice of using remote servers hosted on the Internet to store, manage, and process data, rather than local servers or personal computers. This technology allows libraries to access resources and services dynamically, scaling operations based on demand (Marshall, 2017). In the context of the 4IR, characterised by the fusion of digital, physical, and biological systems, cloud computing enables libraries to adapt to the rapidly changing information landscape (Schmidt, 2020).

Ward (2018) conducted a study on cloud computing in academic institutions in the United Kingdom, and the study established that cloud computing enhances the accessibility and availability of resources. Libraries can now provide access to digital collections, e-books, and databases from anywhere, at any time, through cloud-based platforms. This flexibility supports the 24/7 access expectations of users in the digital age (Swaminathan, 2021). Moreover, cloud storage ensures data redundancy and backup, reducing the risk of data loss due to hardware failure or disasters. According to Dutt (2015), cloud computing also offers cost efficiencies for libraries by reducing the need for extensive physical infrastructure and maintenance costs associated with traditional servers. Libraries can allocate resources more effectively, investing in digital services and user-centric technologies rather than hardware upgrades. This shift allows libraries to reallocate funds towards enhancing user experiences and expanding digital collections (Lewis, 2019).

Adegbilero-Iwari and Hamzat (2017) conducted a study on library services platform path to cloud computing adoption in Nigerian academic libraries. The study revealed that the scalability of cloud computing enables libraries to scale services up or down based on demand,

accommodating fluctuations in user activity or resource needs. This flexibility is crucial in the 4IR context, where technological advancements occur rapidly, requiring libraries to adapt quickly to new information formats and user expectations (Swain, 2014). Cloud platforms also support collaborative projects and resource sharing among libraries, fostering a global network of knowledge dissemination. The study by Adegbilero-Iwari and Hamzat emphasised the scalability and flexibility of cloud computing in Nigerian academic libraries while the current study focused on local challenges, such as infrastructure, lack of funding, and lack of technique skills for librarians to manage 4IR Technologies. Additionally, the study in Zambia would benefit from exploring how local libraries are integrating emerging technologies into their services and the impact on users' expectations, compared to broader trends observed in Nigerian academic libraries.

Ward (2018), postulates that cloud computing facilitates data analytics in libraries, enabling institutions to gather insights into user behavior, preferences, and trends. By analyzing data collected from cloud-based systems, libraries can personalize services, recommend relevant resources, and optimize collection development strategies (Schmidt, 2020). This personalized approach enhances user satisfaction and engagement, aligning with the goals of the 4IR to leverage data-driven decision-making . While cloud computing offers numerous benefits, libraries must also address security and privacy concerns. Storing sensitive patron information and intellectual property on cloud servers requires robust security measures and compliance with data protection regulations (Birchall, 2019). Libraries must carefully select cloud service providers that prioritize data security and offer transparent policies regarding data handling and privacy (Lewis, 2019).

Cloud computing plays a pivotal role in digital preservation efforts within libraries, ensuring long-term access to cultural heritage materials and scholarly research. By migrating digital collections to cloud-based archives, libraries can mitigate risks associated with format obsolescence and technological changes (Dutt, 2015). Cloud storage solutions provide the infrastructure needed to preserve and provide access to digital assets for future generations (Swain, 2014). Cloud computing fosters collaboration and knowledge sharing among libraries and their communities. Through cloud-based platforms, libraries can participate in collaborative digitization projects, share resources across institutions, and engage in global scholarly communication networks (Adegbilero-Iwari, and Hamzat, 2017). This collaborative approach supports the principles of openness and accessibility promoted by the 4IR, facilitating broader access to information and research (Muazu, 2023).

Azam (2019), states that the adoption of cloud computing in libraries necessitates new skill sets among library staff, including proficiency in cloud-based platforms, data analytics, and information security. Training programs and professional development initiatives are essential to equip library professionals with the knowledge and expertise needed to leverage cloud technologies effectively (Ward, 2018). Libraries must invest in workforce development strategies to ensure that staff can adapt to technological advancements driven by the 4IR.

2.2.7 Automation

Automation in library services offers a host of benefits that enhance efficiency, accessibility, and user experience. One significant advantage is improved access to information. Automated systems enable libraries to catalogue and organise vast amounts of information swiftly and accurately, making it easier for patrons to locate resources. For instance, integrated library systems (ILS) streamline tasks such as cataloguing, circulation, and inventory management, thereby freeing up librarians to focus more on patron assistance and specialized services (Joseph, 2019). A study by Robinson (2012), revealed that automation facilitates remote access to library resources, a crucial benefit in today's digital age. Patrons can search catalogues, reserve books, and access electronic resources from anywhere with an internet connection, expanding the reach of library services beyond physical boundaries (Crawford, 2018). This increased accessibility not only accommodates diverse user needs but also promotes lifelong learning and research.

Gundakanal (2023), noted that another notable advantage is the potential for cost savings and resource allocation. Automated systems can reduce operational costs associated with manual processes, such as labour-intensive cataloguing or inventory management tasks. By reallocating resources towards digital initiatives or enhanced collections, libraries can better meet evolving user expectations and technological advancements (Mishra et al., 2015). According to Bwalya and Mkulama (2024), automation in library services also presents challenges that must be addressed. One major concern is the digital divide, where certain populations may lack access to the technology or skills required to navigate automated systems effectively. Librarians play a crucial role in bridging this gap by providing training and support to patrons, ensuring equitable access to information (Aqili and Isfandyari-Moghaddam, 2008).

2.3 The Fourth Industrial Revolution Influence on Information Access and Retrieval Methods in Libraries

The 4IR has significantly transformed information access and retrieval methods in libraries through the integration of advanced technologies such as artificial intelligence, big data, the Internet of Things (IoT), and cloud computing. These innovations have enabled libraries to automate cataloguing, enhance search capabilities with intelligent systems, and provide personalized user experiences. Digital repositories and online databases are now more accessible, allowing users to retrieve information remotely and in real time. Consequently, libraries are evolving into smart, data-driven spaces that support seamless and efficient information discovery in the digital age.

2.3.1 Digitisation of Collections

One of the most visible effects of the 4IR on libraries has been the increased digitisation of holdings. According to Besser (2002), the process consists of turning physical materials such as books, papers, and journals into digital representations that can be accessed online. Similarly, Sony and Naik (2020), also postulates that digitalisation improves accessibility by removing geographical barriers and allowing users to access resources remotely. For example, the British Library's digitalisation efforts have made rare manuscripts and historical records accessible to a global audience, transforming scholarly research. According to the NMC Horizon Report (2017), the shift in attention to digital resources will directly affect the job of library professionals, who will need to master developing skills to create the potential to use the latest technology for teaching, learning, and research.

According to Otike (2023), libraries have begun to automate their services by employing digital technologies such as online catalogues, e-books, and digital archives. The authors also pointed out that this shift toward digital transformation is critical for libraries to remain relevant in the face of rising student expectations for technology-enabled services. Besser (2002) also adds that libraries may now effectively digitise rare and delicate objects, since high-resolution scanning technology have proliferated, guaranteeing their long-term accessibility and preservation for future generations. Furthermore, the incorporation of machine learning algorithms streamlines the organisation and search ability of digital collections by enabling automated labelling, categorisation, and metadata extraction from digitised resources (Liu, and Sheng, 2017). These developments provide for easy access to an abundance of digital

resources, which improves user experiences while also increasing the efficiency of library operations.

Zhang (2015), carried a study on the convergence of digital humanities and digital libraries in the United State of American and the study selected only 69 articles for review based upon the criteria of subject representativeness, geographic balance, and authors' credentials. The study found that the 4IR has accelerated the development of new digital humanities programs within libraries. Institutions are increasingly using technologies like natural language processing, data visualisation, and virtual reality to create immersive digital exhibits and interactive learning experiences. Zhang's study highlighted the integration of advanced technologies like natural language processing, data visualisation, and virtual reality in U.S. libraries, it does not specifically address how these innovations have impacted academic libraries in developing countries like Zambia.

Suber (2012) also found that the 4IR has accelerated the implementation of open access programs in libraries. With the growing demand for publicly accessible scholarly literature, libraries are adopting open access publishing formats and digitising their holdings to make them available to a global audience. For example, the Digital Public Library of America (DPLA) collects millions of digitised documents from libraries, archives, and museums around the United States, giving people free access to a massive storehouse of cultural relics and scholarly publications (Gore, 2011).

Furthermore, the 4IR has encouraged academic libraries to reconsider their role as cultural gatekeepers and support collaborative digitalisation activities. Institutions are increasingly collaborating with external stakeholders, such as other libraries, museums, and technology businesses, to digitise and distribute cultural heritage items (Sonnenwald et al 1999). For example, the British Library's "Two Centuries of Indian Print" initiative works with Indian institutions to digitize rare Indian books and manuscripts, promoting cross-border cultural and scholarly exchange (Finn et al., 2019). Libraries can broaden and deepen their digital collections by harnessing the combined skills and resources of various partners, so improving scholarly inquiry and cultural understanding in the digital age.

2.3.2 Embracing Open Access Initiatives

A study conducted by Brunsting, Harrington, and Scott (2022), revealed that the 4IR has spurred the expansion of open-access initiatives in academic publication, resulting in more

knowledge democratisation. Libraries play an important role in advancing open access by hosting institutional repositories, campaigning for open-access regulations, and promoting open-access publications and platforms. Initiatives such as the Directory of Open Access Journals (DOAJ) and the Open Library of Humanities (OLH) enable free and unfettered access to scholarly literature, encouraging collaboration and innovation (Suber, 2012). This view is supported by Ocholla and Ocholla (2020), and Abubakar (2011), who argue that academic libraries are increasingly compelled to deliver services to their customers rather than being only or primary providers of knowledge. Instead, individuals use libraries to identify multiple pathways to the knowledge they seek and draw on library services to support their (mostly) independent search for information and resources.

This transformation of open access has prompted a dramatic shift in libraries' attitudes regarding open access efforts. Isiaka (2024), defines open access as the free, unrestricted availability of scientific research literature, allowing anyone to read, download, copy, distribute, print, search, or link to the complete texts of these articles. This movement is motivated by the conviction that access to information should not be limited by financial constraints. The Fourth Industrial Revolution has increased the adoption of open access efforts in academic libraries by emphasizing digital connectivity, collaboration, and innovation.

Christopher and Yusuf (2018) on their study towards the revolution and democratization of education a framework to overcome challenges and explore opportunities through industry 4.0 in Brazil found that the 4IR has also promoted open-access programs in libraries by democratising information access. Libraries are now better equipped than ever to digitise their holdings and make them freely available online. This has resulted in the creation of digital repositories and institutional archives where scholarly works can be preserved, managed, and disseminated without incurring costs. According to Bailey (2008), the Fourth Industrial Revolution has enabled libraries to become open-access publishing hubs, allowing for worldwide knowledge exchange and cooperation. Opele (2023) and Tan and Ng (2020) also investigated the impact of emerging technologies in transforming library services in libraries, however the studies will mostly focus on Western contexts.

The studies Christopher et al. emphasised the global democratisation of information, open-access programs, and the digitisation of library holdings, they predominantly reflect developments in advanced economies. The gap exists in understanding how these technologies are being implemented and their unique impacts in an African setting, such as Zambia, where

challenges like limited infrastructure, digital literacy, and financial constraints may shape the pace and scope of 4IR adoption in academic libraries.

Isiaka (2024), researched on the impact of the Fourth Industrial Revolution on novel publishing models, and the findings demonstrated that the Fourth Industrial Revolution promoted the creation of new publishing models that promote open access. Libraries are increasingly collaborating with researchers, research institutions, and funding agencies to promote alternative publishing efforts like open-access journals, preprint servers, and open educational resources. For example, projects such as the Open Library of Humanities and arXiv have gained traction, allowing scholars to share their work openly and freely. As stated by Björk (2017), the Fourth Industrial Revolution has accelerated the diversification of publishing techniques, disrupting traditional subscription-based models and creating an open and accessible culture in academic publishing.

In a similar study, Mudry (2015) found that the Fourth Industrial Revolution has raised awareness of the societal benefits of open access in academics. As digital technologies continue to revolutionize how information is created, communicated, and consumed, there is an increasing realization of the need of making research findings publicly available in order to address global concerns and spur innovation. Libraries are increasingly campaigning for open access rules and mandates at the institutional and governmental levels to ensure that publicly funded research is available to everyone. This is consistent with the goals of the Open Science movement, which aims to increase research transparency, collaboration, and accessibility. According to Schöpfel (2013), the Fourth Industrial Revolution has sparked debates over libraries' position as champions of open access and drivers of societal change.

2.3.3 Expansion of Collaborative Spaces

In response to changing user requirements and educational approaches, libraries are upgrading their physical locations into collaborative hubs outfitted with innovative technology. These spaces allow for interdisciplinary cooperation, group study sessions, and interactive seminars (Brunsting, Harrington, Scott, 2022). The University of Toronto Libraries, for example, remodelled its spaces to include collaborative workstations, multimedia studios, and maker spaces, encouraging students and researchers to be creative and share their knowledge. Such surroundings encourage serendipitous meetings and collaborative learning opportunities. Libraries, too, must promote innovation, entrepreneurship, new knowledge development, and knowledge exchange, as well as successful collaboration and communication. Because

continuous learning is vital, strategies must focus on discovering new ways to build skills and knowledge while maintaining and providing services in the present (Christopher and Yusuf, 2018).

According to Rasmussen (2019), one of the most notable effects of the Fourth Industrial Revolution on collaborative spaces in academic libraries is an emphasis on digital literacy and technological integration. Libraries have invested in building places equipped with cutting-edge technology such as interactive displays, multimedia production studios, and virtual reality labs, as research and learning rely more on digital tools and resources (Choi, 2020). These technologies not only enable collaborative work, but also allow users to interact with material in novel ways, cultivating creativity and critical thinking abilities that are crucial for success in the digital age.

Kietzmann (2016) conducted a study on the 4IR and higher education in the United State of America and the study established that the 4IR has accelerated the shift to multidisciplinary collaboration and project-based learning in higher education. Libraries have responded by creating flexible and adaptable spaces that can support a wide range of users participating in collaborative projects across disciplines. These spaces frequently include modular furniture, adjustable dividers, and open layouts to encourage interaction and teamwork while enabling for flexibility based on each group's unique demands (Adeogun, 2019). While the study by Kietzmann highlighted the shift towards multidisciplinary collaboration and project-based learning in the U.S., there is a need to assess how these global trends are specifically affecting academic libraries in Zambia.

In a similar study, Luo (2017), found that the 4IR resulted in the democratisation of knowledge and the growth of the open access and open science movements. In response, academic libraries have evolved into open scholarship hubs, offering locations for researchers to cooperate on open-source projects, exchange data and resources, and engage in transparent and reproducible research procedures (Bastos et al., 2021). Libraries play an important role in facilitating research and innovation in the digital age by encouraging an open and collaborative atmosphere.

2.3.4. Development of Mobile Applications

The 4IR had a profound impact on the development of mobile applications in libraries. These applications are critical tools for easing resource access, improving user experience, and

encouraging academic community interaction. One of the impacts of the 4IR is the widespread use of smartphones and mobile devices (Kumar, 2015). As a result, libraries understand the need to tailor their services to the demands of customers who increasingly rely on mobile devices for information access and communication

According to Alawadhi (2019), the 4IR has made it easier to integrate mobile applications with other new technologies, such as blockchain and the Internet of Things (IoT), in order to address various difficulties that libraries confront. For example, blockchain technology can be used to protect the confidentiality and integrity of digital assets accessed via mobile applications, such as scholarly papers or research data. In addition, IoT devices can improve library resource accessibility by giving real-time data on resource availability, location, and consumption trends (Usman and Ullah, 2024). Libraries can employ these technologies to expedite operations, improve resource management, and enhance the overall user experience of their mobile applications.

2.3.5 Focus on User-Centred Design

Libraries are rethinking their services and interfaces based on user-centered design concepts to prioritize user experience and accessibility. Libraries use usability tests, user surveys, and feedback sessions to continuously enhance their websites, discovery platforms, and digital interfaces (Dempsey and Malpas, 2018). The University of Michigan Library, for example, uses human-centered design approaches to improve the accessibility and usability of its online catalogue and research aids (University of Michigan Library, 2020). Libraries guarantee that information access and retrieval methods fit with user preferences and expectations by putting users first in the design process.

Agoh and Omekwu (2021) did a study that looked at library and information services delivery and researchers' scholarly communication outputs in agricultural research institutes in north-central, Nigeria and the study revealed that library and information service delivery are critical to academic libraries. Essentially, library and information service delivery refer to the processes and actions that libraries utilize to provide information services and resources to library users, with the goal of improving library users' activities and productivity. According to Mercy and Afolabi, (2023), library and information service delivery is a collection of mechanisms whose interactions define their effectiveness. Itsekor (2019) opined that librarians are at the forefront of providing information services to respective communities to support their teaching, learning, and research needs. Information services delivered by libraries according to

Itsekor (2019) include referral services (RS), Current Awareness Services (CAS), Selective Dissemination of Information (SDI), Internet Services (IS), Interlibrary Loan Services (ILLS), Reference Services (RS) and Circulation Services (CS).

The studies Agoh et al. focused on traditional and well-established services such as Current Awareness Services, Interlibrary Loan Services, and Circulation Services, they do not account for how emerging technologies, digital tools, automation, and artificial intelligence are reshaping library operations. The introduction of the 4IR could bring new models of service delivery, such as virtual reference services, data analytics, and AI-driven personalised library experiences, which may not have been fully addressed in these earlier studies. An assessment of the 4IR's effect would assess these technological disruptions and their implications for academic libraries in Zambia.

2.3.6 Collaboration with Industry Partners

Libraries are collaborating with industry players to improve information access and retrieval by utilising technology innovations and specialized knowledge. Libraries can obtain state-of-the-art tools, platforms, and resources through partnerships with publishing houses, ISPs, and technology businesses (Lulu-Pokubo and Onwueme, 2024). For instance, the collaboration between Google Scholar and MIT Libraries makes it easier for academic content to be seamlessly integrated into Google search results, increasing the visibility and usability of academic research (Roy and Habib (2024)). These kinds of partnerships foster creativity and allow academic libraries to be at the forefront of scholarly communication and information distribution.

Olubiyo and Olubiyo (2022) investigated academic libraries' collaborative efforts to share resources and knowledge via consortia or partnerships in the context of 4IR adoption. The authors claim that such cooperation can help libraries pool their resources more effectively and utilize economies of scale to develop expensive but necessary technology such as AI or VR systems (ibid). These findings are consistent with Atkinson's (2018) research, which found that academic libraries collaborate with other libraries to exchange resources such as advanced IT resources, expertise, and competence in order to accelerate the implementation of compelling Lib 4.0 technologies and applications.

Horbach and Halfman (2019) argued that libraries have transformed into collaborative venues that enable interdisciplinary collaborations among scholars, students, and industry

stakeholders. These relationships frequently include cooperative research projects, technology transfer initiatives, and industry-sponsored programs that address real-world concerns and drive innovation (Corrall, 2014). Libraries, for example, may host innovation laboratories or maker spaces where researchers and industry partners can work together to prototype new technologies or discover answers to industry-specific challenges (Roy and Habib, 2024).

Weller (2018) conducted a study on data-driven decision-making: real-world effectiveness in industry 5.0 and an experimental approach and the study that found that the 4IR has raised the demand for data-driven decision-making and evidence-based research in academia and industry. Libraries play an important role in this environment by giving access to huge archives of scholarly literature, research data, and specialised tools for data analysis and visualisation. Researchers and industry partners can work more effectively together on data-intensive initiatives and gain valuable insights from complicated datasets by harnessing these tools (Adeogun, 2019). While the study for Weller highlighted the increased demand for data-driven decision-making in industry and academia, the study current study focused on academic libraries having adapted to these shifts, including the integration of 4IR technologies and data tools into their services.

2.4 Skills and Training for Library Staff in Response to the Fourth Industrial Revolution

In response to the 4IR, library staff must acquire new skills and training to stay relevant in an increasingly digital and automated environment. This includes digital literacy, data management, information and communication technologies (ICT), and the use of emerging tools such as artificial intelligence, cloud computing, and digital archives. Additionally, staff should be trained in user-centered service delivery, critical thinking, and adaptive learning to effectively support the evolving needs of users. Continuous professional development and capacity-building initiatives are essential to ensure library staff can navigate and harness technological advancements for improved service delivery.

2.4.1 Understanding Emerging Technologies

Library staff need to be proficient in understanding emerging technologies such as artificial intelligence, machine learning, blockchain, and augmented reality, as these technologies are increasingly shaping the way information is accessed, organized, and disseminated (Gupta and Kundra, 2020). Familiarity with these technologies enables librarians to effectively adapt library services and resources to meet the evolving needs of patrons. Tshabalala and Dube

(2024), noted that the 4IR offers new technological solutions that can address the dilemmas in basic service delivery. However, these solutions might be limited by the access people have to the technology required to acquire the said services.

According to Chidiebere (2023), the use of current tools like library management software, are revolutionising the way technologies are applied in libraries. With development based on three key pillars digital, biological technology, and physics the information and library business has also entered the fourth industrial revolution (also known as Industrial Revolution 4.0). Specifically, the fundamental components of digital development are things like artificial intelligence (AI), the internet of things (IoT), and big data (big data), all of which have a direct bearing on the information and library sector. This is anticipated to significantly alter how consumers are provided with information (Cao, 2019).

According to the Business Coalition for Education (2020), approximately 1.8 billion youngsters might lack the necessary skills by 2030 due to automation and 4IR technologies and applications, necessitating the incorporation of these disruptive technologies into school curricula. In a similar vein, the University of Calgary (2020) and Schwab (2016) advocate for curriculum reforms in schools and higher education to incorporate necessary technologies. Similarly, Lase (2019) discovered that academic courses should be changed to embrace Lib 4.0 to generate graduates who are digitally savvy and capable of using Lib 4.0 applications.

In light of this, librarians are being urged to be assertive and proactive in examining their resources and services in order to secure a spot in the 4IR. Manda and Iqbal and Rahim (2023) call for skilled, innovative, and technologically savvy workers, while Olayinka and Abdulfatai (2024) stressed that librarians need to be able to identify patterns, apply context and intelligence, extract relevant information hidden in large volumes of data, and use digital content developers and user advisors.

According to Kirkwood, H. (2020), a study was conducted at Florida State University on rethinking the roles and skills of information professionals in the context of the Fourth Industrial Revolution (4IR) and study discovered that information professionals need to have cognitive flexibility, emotional intelligence, complex problem-solving, critical thinking, creativity, and people management abilities to survive in the 4IR. Tasks should become more fluid as services become more automated, and information professionals must be adaptable and capable of switching from one duty to the next. The findings are consistent with Ocholla and Ocholla (2020, p.5) who emphasised that "complex problem-solving, critical thinking,

creativity/innovation, people management, coordinating with others, emotional intelligence, judgment, and decision-making" are enticing for information workers. While Kirkwood et al emphasised the need for cognitive flexibility, emotional intelligence, and other soft skills for information professionals to navigate the current study assessed how these skills are integrated into the daily operations of academic libraries, focusing on the challenges and adaptations needed in that specific region.

2.4.2 Data Literacy

With the growth of data in the digital age, library workers must have good data literacy abilities to successfully traverse and analyse huge databases (Cullen and Galassi, 2019). This involves understanding data sources, data formats, data modification techniques, and data visualisation tools, all of which are required to provide data-driven services and aid clients with their research. According to Bühler (2022), change will not wait for us; instead, business leaders, educators, and governments must all take proactive steps to up skill and retrain people so that everyone can profit from the 4IR. As a result, the obligation to develop the models and settings to allow it to occur must be accepted, or else we will consume a generation with a lack of skills for the new demands of the labour market and that turns out to be a huge problem to society. Dube (2021) encourage information professionals to build up their skills and knowledge regarding 4IR technologies to survive even though the extent to which these innovations are adopted is likely to differ from one library to another

Anyakoha (2005) asserts that the modern information environment necessitates that librarians themselves gain knowledge and proficiency, particularly in the areas of electronic publishing, digital information management, modern information and communication technologies, and knowledge management. Put another way, in order for librarians in university libraries to stay relevant, they must develop ICT-based skills. According to a study done by the Associations and Institutions (2021), libraries must embrace new technologies in order to preserve information in all formats, offer reliable and efficient support for political and social engagement, and provide universal access to information and scholarly works.

Similarly, Howard (2018) stated that complex problem-solving and critical thinking should be baseline skills for all librarians in order to meet the diverse information needs of technology-oriented library customers. The study also found that one-third of the abilities considered indispensable for information provision and dissemination will change in the near future. According to Ayinde and Kirkwood (2020), in order for librarians to become vital workers

with broad and complementary skill sets, they must consistently fulfil the changing requirements of technologically savvy patrons and predict that they will grow more sophisticated in the future.

Du Toit (2019) conducted a comprehensive study on the Big 6 information literacy skills that remain important in the 4IR. The survey confirms that academic libraries have recognised the 4IR's inescapable disruptive shifts and are actively promoting the adoption of Lib 4.0 technologies and apps. The author emphasised that integrating advanced Lib 4.0 technologies and apps requires libraries to appropriately train its patrons, particularly students, in order for them to be able to use Lib 4.0 technologies to get relevant information and meet their information demands. They must be able to recognise and "define information problems, learn information-seeking strategies, and develop skills in organising and disseminating information" (Du Toit, 2019, p.12). The study by Du Toit emphasised the need for libraries to train students in using advanced Lib 4.0 technologies and apps to meet their information needs, there may be a lack of systematic implementation and support for such training in Zambian academic libraries.

These findings reflect the conclusions of previous studies by Olayinka and Abdulfatai (2024), who explored how libraries will prepare for the 4IR, and Ocholla (2016), who investigated the new roles of academic libraries in promoting scholarly communication and research. Ocholla and Ocholla (2020), as well as Oke and Fernandes (2020), agreed that academic libraries are pushing information literacy courses, both in-person and virtual, driven by the need to raise smart library professionals and users.

2.4.3 Information Management

The Fourth Industrial Revolution has resulted in an exponential growth in the amount and variety of information available in digital media. To effectively organize, store, and retrieve digital material, library staff must be taught in information management principles and technology (Kim, 2018). This requires familiarity with content management systems, digital asset management technologies, and metadata standards. According to Rogheyeh (2020), some of these technologies appear implausible, but the library's purpose is to satisfy its clients' information needs as effectively as possible. As a result, libraries have no choice but to cooperate to give effective and efficient services. In whatever form it has taken, 4IR will not signal doom for libraries and librarians, but rather upgrade them: staff can now work from

home, the adoption of artificial intelligence, more connections and communications for libraries, online monitoring of staff performance and monitoring services from home.

Adopting new technologies to improve information access and retrieval is an important part of library information management. Digital libraries and internet databases have become vital tools for maintaining and accessing intellectual resources. As Tenopir and King (2004) point out, technological improvements have revolutionized the way libraries collect, organise, and disseminate information, resulting in greater efficiency and convenience for library users. The use of integrated library systems (ILS) and library management software has simplified administrative duties and improved resource use in academic libraries (Cox, 2013).

According to a study conducted by Zhou (2015), rising trends such as open access initiatives and data management services are increasingly influencing library information management practices. Open access efforts seek to make scholarly literature freely available online, hence increasing the diffusion and accessibility of research outputs. Suber (2012) contends that libraries play an important role in promoting open access by hosting institutional repositories and pushing for open-access publishing methods. Furthermore, the increased emphasis on data management services reflects researchers' changing needs for organising and sharing research data effectively. Libraries are also expanding their role by providing support and infrastructure for data curation, archiving, and sharing, which contributes to the research lifecycle.

2.4.4 Digital Preservation

Digital preservation in libraries is an important effort that ensures the long-term accessibility and usage of digital items for scholarly research and education. As the volume of born-digital and digitised content grows fast, libraries must preserve these materials in a variety of formats, such as text documents, photographs, audio-visual recordings, databases, and software programs. The purpose of digital preservation is to reduce the hazards of format obsolescence, medium deterioration, and technological changes that may render digital content inaccessible or unusable over time (UNESCO, 2003)

According to Hazarika (2020), one of the essential ideas that guide digital preservation activities in libraries is the adoption of standards and best practices for digital collection management and care. Standards such as the Open Archival Information System (OAIS) reference model give a conceptual framework for establishing reliable digital archives capable of conserving and giving long-term access to digital content (ISO 14721:2012). Libraries can

assure interoperability, sustainability, and authenticity in digital preservation activities by following established standards (Witt, 2019).

Furthermore, teamwork and collaborations are critical to advance digital preservation agendas within the library community. Given the complexities and resource demands of digital preservation efforts, libraries frequently work with other institutions, consortia, and organisations to exchange expertise, infrastructure, and tools for preserving digital artifacts. Collaborative initiatives like the Digital Preservation Network (DPN) and the Meta Archive Cooperative enable libraries to work together to address common difficulties and harness shared resources for digital preservation (Zarnitz, 2019).

Furthermore, Hamza (2023) did a study on Digital preservation systems and technologies in South African academic libraries and the study adopted a quantitative research approach by using a survey research design with a sample size of 27 academic libraries. The study found that developing strong policies and practices is critical for effective digital preservation in libraries. Policies governing appraisal, ingest, storage, metadata management, access, and rights management provide as a foundation for making informed decisions about digital material selection, acquisition, and administration. Libraries can assure consistency, transparency, and accountability in their digital preservation processes by defining preservation techniques and procedures in official policies and this safeguards the scholarly record for future generations

The gap between Hamza's findings on digital preservation in South African academic libraries and an assessment of the effect of the 4IR on library services in Zambia lies in the focus of technological adaptation and policy implementation. While Hamza emphasised the importance of strong digital preservation policies for managing digital materials in libraries, the current study established how emerging technologies, such as artificial intelligence, automation, and big data, are transforming library services, including access, cataloguing, and user interaction.

2.4.5 User Experience Design

User experience design in libraries is critical for improving student interactions with library resources and services. As educational institutions rely more on digital platforms to access information, creating intuitive and user-friendly interfaces becomes critical. According to Marchionini (2003), "user experience encompasses all aspects of the end-user's interaction with the company, its services, and its products." In academic libraries, this means providing

students and faculty with seamless experiences as they browse diverse library resources, both physical and digital.

One key aspect of user experience design in libraries is the optimization of search interfaces. As noted by Lamba (2022), an academic library's search interface is the primary means by which users access the library's collections and services. Therefore, ensuring that search functionalities are intuitive and efficient is crucial for facilitating information discovery. This involves employing techniques such as user testing and iterative design to understand user behaviour and preferences better. By incorporating features like autocomplete suggestions and faceted search options, libraries can enhance the search experience for their patrons (Hider, 2012).

The accessibility of digital materials is another key factor to consider when designing user experiences for libraries (Panda and Kaur, 2023). With an increased emphasis on inclusivity and diversity, libraries must guarantee that their online platforms are accessible to people with disabilities. This includes following accessibility standards such as the Web Content Accessibility Guidelines (WCAG) and performing frequent audits to identify and address usability issues (Rush, 2014). By prioritizing accessibility in user experience design, academic libraries may ensure that all users, regardless of ability, can effectively interact with library materials.

Furthermore, user experience design goes beyond the digital domain to include the actual environment of libraries. According to Bell (2018), the physical environment of the library remains an important aspect of the user experience. Signage, furniture layout, and lighting are all important considerations for creating a friendly and conducive environment for study and research. Libraries can improve their overall experience by using environmental psychology and human-centered design principles.

The studies by Marchionini et al. emphasised user-centered design, accessibility, and interface optimisation, the current study focuses on how innovations like AI, automation, and data analytics influence library operations and services. Specifically, the 4IR's effect on academic libraries which included automation, enhanced data-driven decision-making, and the use of virtual reality for immersive learning experiences areas that extend beyond traditional user experience principles and require new approaches to technology integration, infrastructure, and skill development.

2.4.6 Information Privacy and Security

Information privacy and security are critical concerns in libraries, where large volumes of sensitive data, including student records, research findings, and intellectual property, are stored and accessed (Panda and Kaur, 2023). Libraries serve as custodians of vast repositories of information, making them prime targets for malicious actors seeking to exploit vulnerabilities for various purposes, including identity theft, financial fraud, and corporate espionage (Sahay 2021). Therefore, libraries must implement robust privacy and security measures to safeguard the confidentiality, integrity, and availability of their digital assets.

Furthermore, libraries must strike a balance between protecting patron privacy and implementing data analytics to improve services and resource allocation. While data-driven decision-making can improve user experiences and optimise library operations, it also raises questions regarding user monitoring and profiling (Massis, 2016). To solve this issue, libraries should implement transparent privacy rules, get express agreement for data collection and processing, and anonymise or pseudonymise data whenever possible to safeguard patron identities.

Lima (2017) conducted a study on digital information security management policy in academic libraries in Pakistan and the study was a systematic review. The study found that information privacy and security are critical in academic libraries to maintain patron trust, comply with legislation, and limit the risks associated with data breaches and cyber threats. Libraries can effectively support scientific endeavours and safeguard the confidentiality of sensitive information by implementing strong security mechanisms, complying with privacy legislation, and fostering transparency in data practices.

The study for Lima's focused primarily on the importance of information security, privacy, and compliance with legislation, the current study assessed how emerging technologies such as artificial intelligence, big data, and automation are transforming library services. This included the integration of these technologies in managing digital resources, enhancing user experiences, and addressing new challenges in digital security within the context of 4IR

2.4.7 Digital Literacy Instruction

Digital literacy education in libraries is becoming increasingly important in today's information-driven culture. With the expansion of digital resources and the prominence of

online information, students must learn how to access, assess, and successfully use digital information (Sinkinson, 2017). Libraries should play an important role in promoting this growth by offering digital literacy teaching targeted to the specific needs of their user groups. Breivik and Gee (2018) define digital literacy as the ability to locate, analyse, and ethically use digital information, as well as grasp the social and cultural ramifications of technology. Thus, digital literacy instruction in academic libraries attempts to equip students to be critical consumers and creators of digital content, rather than simply teaching technical skills; it aims to empower students to become critical consumers and creators of digital content.

Matteson, and Gersch, (2020) stated that one strategy for digital literacy instruction in academic libraries is to incorporate it into information literacy programs. The ability to identify an information need, locate and assess information, and use it successfully serves as the foundation for developing digital literacy skills (Association of College and Research Libraries, 2015). Libraries can ensure that students learn the competencies needed to navigate both the print and digital information landscapes by incorporating digital literacy education into information literacy initiatives. For example, courses on evaluating internet sources or adding multimedia aspects to research projects can help students improve their digital literacy skills within the larger framework of information literacy.

Reichart and Elvidge (2015) conducted research on the role of libraries in promoting digital literacy skills in the digital age in Nigeria. The study found that libraries were increasingly using technology to teach digital literacy in novel ways. Online tutorials, interactive modules, and virtual workshops provide adaptable and scalable methods to reach diverse student populations. These digital tools not only offer practical guidance on how to use digital resources, but they also encourage students to learn independently and become autonomous. Libraries that embrace digital platforms can extend the reach of their instructional programs beyond the constraints of physical space and traditional classroom settings, adapting to the evolving needs and preferences of digital-native learners.

The study by Reichart and Elvidge emphasised digital literacy programs like online tutorials, interactive modules, and virtual workshops in Nigeria, the current study developed a broader impact of emerging technologies such as artificial intelligence, automation, and data analytics on library services. The study in Zambia assessed how these technologies are reshaping library functions, resource management, and user engagement, while Reichart and Elvidge focused more on digital literacy as a primary tool for student empowerment.

According to Hicks and Sinkinson (2017), libraries act as hubs for informal learning and collaboration, allowing students to share knowledge and experiment with digital tools. Creating collaborative spaces with technological resources fosters active learning and the development of digital literacy skills through hands-on exploration and experimentation. Academic libraries help students develop as digitally literate individuals ready for success in the digital age by cultivating a culture of inquiry and innovation.

2.4.8 Collaboration and Networking

In today's library environment, networking and collaboration are essential for innovation, resource sharing, and improved services. According to Lewis (2019), to increase their capacity and satisfy the changing requirements of their patrons, libraries are working more and more cooperatively with other organizations, consortia, and outside partners. These partnerships frequently entail cooperative efforts to establish collections, interlibrary loans, and shared technological infrastructure, which allows libraries to maximize resources while lowering expenses (Sony and Naik, 2020). Academic libraries can improve their ability to assist teaching, learning, and research within their communities by utilizing their combined knowledge and resources.

Consortia are a significant example of library collaboration, bringing together multiple institutions to pursue common aims and address shared difficulties (Ghosh, 2011). Consortia provide resource pooling, cooperative purchasing, and collaborative projects that would be difficult for individual libraries to undertake independently. For example, the Association of Research Libraries (ARL) in the United State is a network of leading research libraries that work together on programs such as scholarly communication, digital preservation, and diversity, equity, and inclusion (Klain–Gabbay, 2018). Libraries can leverage consortia alliances to negotiate favourable licensing terms for electronic resources, improve access to specialist collections, and develop innovative services that benefit their unique user population

According to Kennedy (2018), networking is particularly important for library progress since it allows professionals to exchange ideas, best practices, and knowledge across institutional borders. Professional organizations, seminars, and online forums give opportunities for librarians to connect with colleagues, remain current on developing trends, and seek answers to common problems. These networking activities help to disseminate knowledge and foster a culture of continual learning among professionals. Networking also allows academic librarians to form ties with academics, researchers, and other stakeholders, strengthening

multidisciplinary collaborations and aligning library services with the changing requirements of the academic community (Atkinson, 2018).

2.4.9 Continuous Learning and Adaptability

Kudrina and Matveeva (2021) did a study on the continuous library and information education in the era of digital transformation in Nigeria and the study found that continuous learning and adaptability are essential for libraries to succeed in the rapidly changing landscape of information dissemination and scholarly communication. As technology innovations transform research methodology and user expectations, libraries must stay adaptable to satisfy their users' different requirements. Rehman et al. (2023) also highlight the importance of continual learning for librarians to keep up with new trends and technologies. This emphasises the critical role of librarians as information professionals who must constantly upgrade their skills and expertise to effectively serve the academic community.

The study Kudrina and Matveeva emphasised the global necessity for libraries to evolve with digital transformation and Rehman et al. stress the need for continual skill upgrades for librarians, the current study provided a localised exploration of how 4IR specifically influences academic libraries in that region. This included how technological advancements, such as AI, big data, and automation, are reshaping library operations, services, and the skill sets required of librarians in Zambia

Furthermore, adaptability is essential for academic libraries in responding to changing user behaviours and preferences. With the rise of digital resources and online learning platforms, libraries must change their services and collections to meet the changing demands of students and staff. Daraojimba (2023) emphasise the relevance of user-centered approaches in library services, arguing for adaptability and responsiveness to user feedback. This highlights the importance for academic libraries to embrace adaptation as a key principle in order to remain relevant and effective in supporting scholarly activities.

Posner (2012) proposes that learning and flexibility allow academic libraries to develop and experiment with novel ways to offer information. Libraries can explore new ways to increase user engagement and information access by cultivating an experimentation and risk-taking culture. Tella and Ajani (2022), examine the significance of experimenting in libraries, emphasizing the importance of viewing failure as a learning opportunity. This argues that

academic libraries should provide an environment that stimulates creativity and innovation, allowing employees to experiment with novel ideas and solutions.

2.4.10 Ethical and Social Implications

In today's academic library landscape, ethical and social consequences have a significant impact on policies, procedures, and services. One important aspect is access to information. Providing equitable access to resources for all users, regardless of socioeconomic status or identity, is a core ethical consideration (Salman et al. 2019). Libraries must balance offering access to a diverse range of perspectives while ensuring that items are not damaging or discriminatory. This entails carefully selecting and curating collections in order to encourage diversity and inclusivity while adhering to ethical norms.

Hollis (2019), conducted a study on the importance of user privacy and trust in maintaining academic freedom at the library in the United Kingdom and the study established that privacy and confidentiality are paramount in library services. Users often rely on libraries as safe spaces to explore sensitive topics, conduct research, and access information without fear of surveillance or judgment. Librarians must uphold strict confidentiality policies to safeguard user privacy, particularly in the digital realm where data collection and monitoring are prevalent (Posner, 2012). Adhering to professional ethical codes, such as those outlined by the American Library Association, ensures that users can trust libraries as reliable guardians of their information.

The gap between the findings of Hollis on the importance of user privacy and trust in library services lies in the impact of emerging technologies. While Hollis emphasised the significance of maintaining privacy and confidentiality in traditional library settings, the current study introduced 4IR technologies like artificial intelligence, big data, and cloud computing, which may present new challenges and opportunities for data security and user privacy.

According to Afolayan (2017), observed that fostering information literacy and critical thinking abilities is also a component of ethical consideration. In similar study, Hollis (2019), revealed that libraries are essential in helping users develop these competences so they can successfully traverse the ever-complex information ecosystem. Librarians teach students how to assess sources, separate fact from fiction, and interact critically with knowledge through outreach and training. Libraries help to create knowledgeable individuals who can take an active role in society by providing users with these abilities.

2.5 Challenges Faced by Libraries in Adopting the Fourth Industrial Revolution Technologies

Over the last three decades, the realisation that technology will be a major determinant of the quality of education has contributed to a redefinition of the role of libraries (Thiruppathi and Pub, 2024). The evolution of information and learning environments has pushed libraries to adapt and change. This is in stark contrast to the previous few centuries when libraries were rather stagnant organisations. The rate of technological change is accelerating, and the adoption of technology in libraries has no end in sight. This is because technology is not static; it is ever-changing. Each new generation of technology becomes outdated several times faster than the previous generation.

This poses numerous issues for libraries, as it is their natural tendency to maintain and preserve information and knowledge. Nonetheless, the use of technology has become critical for libraries to accomplish their mission. Failure to adapt technologies means that the library will be unable to successfully meet the needs of its parent institution (Khurram, and Abid, 2020). Libraries will not provide appropriate resources, services, or environments, nor will they support quality research and learning. Technology is a means to an end, allowing libraries to increase the quality of research and education. Failure to adopt technology implies it will fall behind, which is a disservice to the institution it serves.

2.5.1 Financial Constraints

One of the biggest barriers to libraries adopting 4IR technology is the financial burden associated with procuring and deploying these advanced technologies (Mohideen, 2020). Many academic institutions find it prohibitively expensive to purchase and operate cutting-edge technologies such as artificial intelligence (AI) systems, virtual reality (VR) tools, and data analytics platforms. A study of selected libraries in KwaZulu-Natal, South Africa, found that low funding posed a significant barrier for academic libraries to adopt emerging technologies required for the 4IR (Mugwisi, 2018). Cronje (2018) also found that the 4IR provides excellent prospects for information professionals to improve library services and attract more library users, but it is constrained by insufficient finance.

Oke and Fernandes (2020) did a study about the 4IT and challenges in South African higher education institutions and they revealed that South Africa is renowned as one of Africa's top countries for embracing modern technology and innovation, they are hampered by a lack of

funds, which will hinder the implementation of 4IR in teaching and learning. Mohideen (2020), who researched Malaysian librarians' perspectives of the 4IR, discovered that the COVID-19 pandemic will worsen financial conditions and impede libraries' ability to deploy 4IR instruments. Schonfeld and Wolff-Eisenberg (2020) also predicted that the COVID-19 epidemic had a significant negative influence on higher education, as revenue was reduced and academic libraries' dreams of embracing Lib 4.0 technologies were not realised.

A study done by Lukasz (2022) revealed that a concerted effort from stakeholders of libraries in South Africa is needed to support libraries financially. These finding echoes earlier recommendations of Baro and Asaba (2010) who after conducting a study on internet connectivity in Nigerian academic libraries, postulated that academic libraries should not solely depend on the government and the parent institution for funds but should expand their sources for example internally generated funds and local or international sponsorships.

Dadzie and Van der Walt (2015) conducted research on the planning of digitalisation in Ghana's university libraries. According to the study's findings, digital transformations account for 16.6% to 50% of the entire budget. The report suggested that academic libraries increase their budgets by integrating domestically produced funds from the leasing of auditoriums and other facilities for activities. The study underlined the value of a specific policy on money generation to be allocated for digital transformation and strong leadership to make university libraries financially stable for the future digital revolution. Hussain and Parveen's (2021) research on the availability of ICT facilities in libraries indicated that IT support for libraries is a significant barrier, forcing libraries to lose technologies in which they have invested. According to the survey, there is a paucity of IT competence among librarians who can manage technological challenges, making it difficult to obtain support from elsewhere/outsource.

The gap between the findings of Dadzie and Van der Walt and Hussain and Parveen and the current study lies in the focus of digital transformation and ICT support. While Dadzie and Van der Walt emphasised the importance of financial planning and leadership to fund and drive digitalisation in Ghana's university libraries, and Hussain and Parveen highlight the lack of IT competence and support within libraries, this study established the readiness of local academic libraries for emerging technologies, their financial strategies, and how they overcome the same barriers to IT support.

2.5.2 Lack of Technical Expertise

Another key difficulty identified by Jain (2023) is a shortage of technical skills among library workers successfully use and administer 4IR technology. Implementing technology such as machine learning algorithms or blockchain systems necessitates specialised knowledge and skills, which may not be readily available in typical library environments. In their study on supporting teaching, learning, research, and recreation, Jain argued that library staff should have specialised skills that improve the delivery of effective library and information services to meet the changing needs of university clients.

Yuvaraj (2016), contends that change is the challenge that leads to the gateway of development via human curiosity and intelligence, resulting in societal transformation. He concludes that a modern library serves as an ASA digital information hub, requiring a skilled, techno-friendly librarian to manage information explosion and satisfy the user community through consultancy services, quick access, quick retrieval, and instant dissemination of information in various formats, such as text, audio, video, image, and multimedia, which are easily created, stored, organised, accessed, and transmitted. The format in which information is sent in the 4IR is treated as a commercial commodity and a valuable resource in industrialised countries, with a high premium placed on time and ease of information transmission.

On the contrary, Tella (2020) argues that the impact of the 4IR has already been felt, therefore, there is no need to dream or imagine how the disruptive changes will affect libraries. In the same token, Hattingh (2018, p.1) maintained that the future is already here therefore “It is not correct to talk about the future world of work”. In light of this, libraries should wake up quickly to strategically respond to the demand of the 4IR. Ocholla and Ocholla (2020) maintained that the COVID-19 pandemic where lockdown was mandatory and discouraged physical meetings to avoid the spread of the novel virus epitomises the reality of how the 4IR will be where patrons should be able to access library resources digitally anywhere without worrying about been physically present.

These findings will echo by Mhlanga and Molo (2020) who found that, during the outbreak of COVID-19 when the lockdown was necessitated, various forms of 4IR will swiftly implemented by various institutions across the world. South Africa, for instance, has been hailed by several authors for leading 4IR in Africa. Emphasizing these findings Ayinde and Dube (2021) explored rethinking the roles and skills of information professionals, in the 4IR.

The study highlighted a great opportunity for librarians to embrace the various 4IR tools to provide innovative support to patrons to meet their information needs

The studies highlighted global and continental trends, particularly in South Africa and the challenges identified by authors like Jain and Yuvaraj, there is a lack of focused research on how academic libraries in Zambia are specifically responding to 4IR. This gap included the unique challenges they face in terms of technical skills, infrastructure, and the readiness to implement and utilise advanced technologies like machine learning, and blockchain as well as the effect of regional factors such as access to technology and trained personnel.

2.5.3 Resistance to Change

Resistance to change in libraries can be compounded by organisational systems that promote continuity over innovation. According to Vos and Rupert (2018), hierarchical structures inside libraries can obstruct the flow of information and decision-making, making it difficult to implement changes efficiently. Furthermore, power dynamics inside the organisation may influence resistance, as individuals or groups with strong interests in maintaining the status quo may aggressively oppose change initiatives. This aversion is especially strong in institutions where decision-making is centralised and top-down, which limits prospects for collaborative problem-solving and innovation among library staff.

According to Cervone (2011), dealing with resistance to change in libraries necessitates a multidimensional strategy that considers the intricate interactions between organisational culture, personal attitudes, and structural impediments. Library leaders may assist in reducing resistance and promoting a more dynamic and responsive organisational environment by encouraging an open attitude to new ideas and offering opportunities for staff training and development. Furthermore, encouraging a sense of empowerment and ownership among library staff members can be achieved by integrating them in the change process through participatory decision-making and open communication, which can assist develop buy-in and support for suggested changes (Cervone, 2011).

Other authors, such as Ayinde and Kirkwood (2020), Park (2018), and Park et al. (2018), have discovered that education and training are the most effective ways to remove staff resistance to change, motivate them, and help them acquire the necessary skill set to be smart, qualified, competent, adaptive, creative, innovative, critical thinkers, complex problem solvers, and self-learners. It was also discovered that university libraries must operate smarter using novel tactics

such as open-access information highways and researcher collaboration. The collaboration will not only allow members to benefit from one other's ideas, but it will also assist academic librarians in developing the digital competences they need to survive.

Thompson and Mayhorn (2012) contended that technological hurdles and attitudinal constraints make it difficult for elder library staff to adopt new technologies that are compelling for service offering. Schwab (2016) hypothesised that because the digital system is always being upgraded, older workers find it challenging to keep up with technological advancements in the workplace. According to Penprase (2018), technophobia stems from a lack of adaptability, self-directed learning, and competence among workers. Yang's (2019) study on the 4IR and older workers concludes that the rapid development of the 4IR's disruptive technologies has produced fear of technology and even technophobia, particularly among older workers, resulting in resistance to new smart technologies.

The gap between the findings in the literature and the current study lies in the specific context of academic libraries in Zambia. While existing research addresses general challenges such as hierarchical structures, resistance to change, and technophobia among older staff, there is limited exploration of how these issues specifically manifest in Zambian academic libraries, especially in terms of 4IR technologies. The unique socio-cultural, economic, and technological landscape of Zambia may present additional barriers or opportunities for the adoption of smart technologies and innovation in library services, requiring a more localized and context-specific analysis.

2.5.4 Privacy and Data Security Concerns

The introduction of 4IR technology into academic libraries poses serious privacy and data security concerns. Technologies like IoT devices and cloud computing solutions capture massive volumes of user data, prompting concerns about data security, confidentiality, and GDPR compliance (Chang, 2018). Limited financial resources, a lack of technological experience among library staff, and concerns about data privacy and security are key impediments to the widespread adoption of these technologies (Al-Suqri, and Akomolafe-Fatuyi, 2012)

According to Gole and Shinde (2001), one of the most pressing concerns in libraries is the acquisition and preservation of personally identifiable information (PII) about library users. This includes information such as names, addresses, and borrowing histories, which are

frequently required for library services but might pose privacy hazards if handled improperly. Libraries must maintain stringent confidentiality regulations to protect patrons' privacy rights. According to the American Library Association's (ALA) rules, libraries should only gather data that is required for library operations and keep it secure from unauthorised access. Implementing anonymization techniques and data minimisation strategies can help to avoid these risks while maintaining critical library operations.

Concerns regarding data privacy overlap with issues of intellectual freedom and censorship in the context of scholarly communication. Academic libraries serve an important role in giving access to varied perspectives and contentious materials; nonetheless, the collecting and dissemination of such resources might draw unwanted attention from external actors aiming to suppress or monitor academic conversation. In response, libraries must support intellectual freedom ideals while simultaneously taking steps to protect users' privacy and ensure the anonymity of their research activities (International Federation of Library Associations, 2015). This could include anonymizing usage statistics and rejecting external temptation to reveal information about library customers' reading habits or research interests.

According to Nwaohiri (2013), the growing reliance on third-party contractors for library services presents new challenges in terms of privacy and security. Many libraries use third-party suppliers for integrated library systems, discovery platforms, and digital resource distribution, which exposes library data to extra threats beyond their direct control. To address these concerns, libraries should thoroughly review suppliers' data handling methods and negotiate contracts that prioritise user privacy and data security (ALA, 2018). Participating in collaborative activities with other libraries and consortia can also increase collective bargaining power and promote the adoption of better privacy standards throughout the library ecosystem. According to a study by Ocholla (2019), in the digital age, university libraries have a critical duty to protect privacy and guarantee data security. Libraries can reduce privacy threats and create a secure and private environment for their patrons by following set policies, putting strong cybersecurity measures in place, respecting the values of intellectual freedom, and exercising caution when interacting with outside suppliers.

2.5.5 Infrastructure Limitations

Many libraries have infrastructure limitations that prevent the seamless integration of 4IR technologies into their existing systems. Outdated IT infrastructure, low bandwidth, and poor network capabilities can all impede the effective deployment of innovative technology

solutions. According to Gole and Shinde (2001), the most significant difficulty facing Nigerian libraries is finance. In the face of limited resources, it is not possible to provide better, effective, efficient, and sustainable information services, as well as access to a diverse range of knowledge and information sources. Funds are required to provide a wide range of services in 21st-century libraries, but government subsidies in the education sector are insufficient (Amaechi, 2018). This undoubtedly reinforces the concept that fund is a prerequisite for effective management of university libraries in the digital age.

Similarly, Mashiyane et al. (2020) at North-West University in South Africa discovered that inadequate ICT infrastructures have hampered academic libraries in South Africa, where disruptive technologies are rapidly becoming indisputable. The survey also found that the library lacked a plan for dealing with an emergency using technology. The recent COVID-19 outbreak was given as a practical example of a lack of tools enabling the library to go fully online in order to avoid a disruption in library service delivery.

Ocholla (2019) investigated the responsiveness of South African libraries to research support in the 4IR, whilst Manda and Blackhouse (2017) investigated the problems and opportunities in the 4IR in developing nations. This research discovered that a lack of ICTs, limited broadband for internet connectivity, a lack of high-tech equipment, and poor digital connectivity will impeding the seamless transition to smart societies, particularly in the library. The authors also expected that many university libraries will face significant challenges in implementing Lib 4.0 due to inadequate ICT infrastructure. Khan and Bhatti's (2017) investigation in Pakistan found the similar tendency. Ghanaian research by Antwi, Ankrah, and Frimpong (2020) and Darko Adjei and DarkoAdjei (2018) confirmed that inadequate ICT infrastructure in academic libraries resulted in unsuccessful attempts to implement digital library services.

Chukwusa (2015) conducted a study on lack of infrastructure in African universities and the study revealed that most universities indulge in self-generation since the capacity for generation, transmission, and distribution has been defective. Insufficient ICT infrastructure is also a major constraint. The low bandwidth level, poor network systems, unavailability of requisite hardware and software are among the infrastructure which is not adequately provided in the library. Ubogu and Okiy (2011) observed that a poor infrastructure is the bane of Information and Communication Technology development in Sub-Saharan Africa. Quality digital library services thrive on the basis of standard and adequate infrastructure

According to Surindra (2024), in developing countries, there is evidence of poor ICT infrastructure, and this is thus one of the major challenges likely to confront their bid to implement industry 4.0 in the country. There are issues with low broadband penetration in developing countries compared to developed economies that are considered leaders in broadband and other ICT infrastructure (United Nations, 2014; International Telecommunication Union, 2015). These will affect the libraries in their adapting to these new technologies. Iqbal and Rahim (2023) add that most countries are still backward in terms of technological and infrastructure development. Zhou (2015) identified such challenges surrounding the introduction of new technologies such as analytics, development of networks and smart devices. These technological and infrastructure challenges will affect libraries in their library service delivery

The gap between the findings from Surindra et al. which highlighted technological and infrastructure challenges in developing countries, the current study lies in the context-specific evaluation of how these global issues directly impact academic libraries. While the general challenges of poor ICT infrastructure, low broadband penetration, and technological backwardness were well-documented, there was need to focus on how these challenges manifest within Zambian academic libraries.

2.5.6 Accessibility Challenges

Libraries must also ensure accessibility for all users, including those with disabilities. Many libraries struggle to provide fair access to their services and resources as a result of physical impediments, obsolete technology, and inadequate accommodations. According to Thompson et al. (2012), failing to address accessibility issues not only breaches legal requirements, but also contradicts the library's commitment to inclusivity and diversity. Overcoming accessibility difficulties necessitates proactive actions such as building improvements, assistive technology investments, and staff training programmes. Jaeger (2015) emphasised that the library's primary focus should be on future awareness in order to strategically and comprehensively prepare for the unknown. Libraries must gradually shift from passive to active involvement in the delivery of library services (Chiparausha and Chigwada, 2019)

Gaspar and Cruz (2019) carried a study on the evolving role of libraries in the fourth industrial revolution: navigating digital transformation at the University of Nebraska-Lincoln and the study discovered that libraries are now making a concerted effort to raise awareness about the 4IR and its expected disruptive developments through workshop training and consultation

sessions. This endeavour is aimed not only at library workers, but also at stakeholders, policymakers, donors, philanthropists, and government officials. According to Gaspar, Juliao, and Cruz (2019, p.8), "the ability to correctly interpret and perceive these changes will allow current and future workforce gains a higher level of awareness to prepare and adapt and allow the organisational alignment with such work paradigm change". The authors emphasised that social relational skills (such as emotional intelligence or negotiation abilities), intercultural and communication, collaborative, and digital skills should be the primary focus of libraries to invest in as they welcome the unavoidable disruptive changes of the 4IR.

Hussain (2019) researched the Fourth Industrial Revolution and its implications for libraries and librarians, discovering that librarians will be aware of the 4IR's impact. However, the study found that all librarians should be proactive in preparing themselves to handle the inevitable disruptive changes in order to keep their jobs and remain relevant in providing library services to their clients. Similarly, Tella (2020a, p.1) stated that "libraries will need to be aggressive and review their resources and services so that they will be relevant, have a place, and be functional in the 4IR era". Frederick (2016) further confirms that while many librarians are aware and have some level of awareness of the 4IR, few are aware of how the 4IR may be completely utilised to improve the provision of library services.

Ntlotlang (2019) did an extensive qualitative research at the Botswana International University of Science and Technology, revealing that academic libraries in Botswana have begun to leverage digital technologies to provide innovative services to technology-driven patrons, meeting the 4IR's unprecedented demand. The data demonstrate that libraries are aware and working proactively to promptly react to the clear demand of the 4IR. Isiaka (2024) discovered that libraries are gradually replacing traditional library services with advanced solutions that allow patrons to access library content digitally. The findings are consistent with those of Mashiyane, (2020), who investigated the awareness and application of multimedia content for information literacy instruction at North-West University in South Africa and discovered that most academic librarians will be aware of the critical importance of Lib 4.0 but will be more interested in Lib 4.0 tools that they will be familiar with and could easily use, such as LibGuides.

Khan and Bhatti (2017) stated that libraries in Pakistan are advocating for digital platforms to meet their users' diverse information demands. The Botswana International University of Science and Technology, for example, offers digital library guides, social media, and e-learning management tools to make digital content more accessible (Ntlotlang 2019). Olayinka and

Abdulfatai (2024), conducted a literature analysis to determine how libraries are preparing for the 4IR and discovered that libraries are implementing measures such as assigning enough resources, establishing effective business models, and practicing good organisational behaviour. The study concluded that libraries will not be in a better position to exploit digital services unless they improve their abilities to ensure that all of these variables are in place, they will not be in a better position to leverage digital services to their maximum.

Ocholla and Ocholla (2020) cited several examples, including "the Capstone Carnegie Conference organised by the University of Pretoria in March 2019, the 20th IS Annual conference organised by the University of Zululand in September 2019, and the University of Johannesburg's 4th Industrial Revolution and Library Practices Conference in October 2019. The authors also said that these conferences have raised significant awareness of the 4IR. In addition, the 2016 China Library Annual Conference, titled "Makerspaces: Creativity in the Library," provided information about Makerspaces. The primary goal of the conference was to focus the attention of librarians on the provision of Makerspace services, which is compelling in the 4IR. Again, at the Emerald Librarian Conference 2018, resource staff attentively provided insight into "preparing libraries for the fourth industrial revolution" (4IR) (Olayinka, and Abdulfatai, 2024, p.1). The respondents will informed on four strategic steps that various libraries might take to prepare for the inevitable disruptive changes brought about by the Fourth Industrial Revolution.

AFLIA (2020) announced its 4th Conference and 6th African Libraries Summit, which will focus on the '4IR, sustainable development, and African libraries', and stated that it hopes to help introduce information professionals to strategies they can use to prepare for the 4IR, which is already here. During the events, attendees will be able to learn about 4IR first-hand, ask questions, and connect with experts. Additionally, a Blockchain National Forum in August 2018 was organised at Mississippi Stated University, where 26 famous professionals introduced librarians to Blockchain and how it may be utilised to improve information services (Zhang, 2019).

2.5.7 Digital Divide

The digital divide in libraries is a complex problem that includes differences in how different user groups use and have access to digital materials and technology (Choi, 2019). This disparity can take many different forms, such as variations in computer literacy, internet connectivity, online database access, and use of digital library services. In order to guarantee fair access to

information and learning opportunities for all users, libraries must bridge this gap as they become more and more dependent on digital resources to support teaching, learning, and research. One key feature of the digital divide in university libraries is the difference in internet connectivity between students and teachers. According to research, people from low-income or rural locations may have restricted access to high-speed internet, which can make it difficult for them to fully utilise digital library services. Furthermore, even on campus, discrepancies in Wi-Fi connectivity or computer terminal availability might compound the digital divide, disproportionately harming marginalised student communities (Jackson and Choi, 2019).

Yuvaraj (2016) observed that gaps in computer literacy and technological abilities exacerbate the digital divide in academic libraries. While some students may be comfortable browsing online databases and using library research tools, others may struggle due to a lack of experience or training in digital literacy (Aqili, 2008). This disparity in digital competencies might impede students' capacity to conduct thorough research, critically assess material, and effectively use library resources to support their academic objectives. Access to scholarly journals and online databases, which are crucial tools for academic research, is another area where the digital divide exists. For many institutions, especially smaller schools or universities with tighter finances, the subscription fees for these digital resources may be unaffordable (Luo, 2020). Due to limited access to scholarly material, these institutions' teachers and students may be at a disadvantage when compared to those at institutions with more financial means.

Tenopir (2009), adds that a holistic strategy that includes infrastructure development, digital literacy initiatives, and equal access to online resources is needed to address the digital gap in academic libraries. By offering technological training courses, increasing access to digital materials through consortium agreements or open access projects, and supporting laws that support widespread high-speed internet access, libraries can significantly contribute to closing this gap (Salinas, 2003). Academic libraries can achieve their goal of giving everyone in the academic community equitable access to information and knowledge by making efforts to close the digital divide a top priority.

2.5.8 Copyright and Intellectual Property Issues

According to Warren (2020), copyright and intellectual property issues are critical challenges for libraries, affecting their ability to provide access to knowledge while respecting the rights of authors and publishers. One crucial part is navigating the difficulties of fair use, which

permits copyrighted material to be used for teaching, research, criticism, and news reporting. Libraries must continuously evaluate fair use factors, such as the purpose and character of the use, the nature of the copyrighted work, the amount and significance of the piece used, and the impact on the potential market. Crews (2001) describes fair use as a flexible doctrine, although its implementation can be difficult, necessitating careful evaluation of particular circumstances.

Suber (2012), noted that the digital age has created new challenges and opportunities for libraries in terms of copyright and intellectual property. Digital collections, electronic reserves, and online course materials have increased access to knowledge while raising concerns about licencing agreements, digital rights management, and preservation. Librarians must handle these difficulties while balancing access with copyright holders' rights. According to Crews (2010), digital technologies have blurred the barriers between traditional library operations and publishing activities, forcing libraries to develop new techniques for managing intellectual property.

Chemulwo (2017) did a study managing intellectual property in digital libraries and copyright challenges in Kenya and the study adopted a descriptive survey research design. Data was collected from a targeted population comprising of 86 academic staff, 23 library staff in charge of e-content and 4 university librarians from four selected universities. Findings showed that the layout of content was unappealing, no clear paths for navigation, use of images and colour for attraction was lacking while search features were complicated to understand. The visual design in the digital platforms lacked user consideration and did not adequately facilitate effective access and utilization of information. The study concluded that visual design is an important component in digital resource platforms for attracting users to access and utilize digital information, hence the need to develop user-centered platforms.

The gap between the findings of Chemulwo's study on intellectual property management in digital libraries and the current study lies in the evolving technological context. While Chemulwo's study highlighted issues with the visual design and user experience of digital platforms, focusing on how these hinder information access, this study assessed how advanced technologies such as AI, automation, and data analytics are transforming library services beyond just design, potentially improving accessibility, and user interaction

Ashikuzzaman (2024), suggested that libraries are essential for advancing alternate modes of scholarly communication and open access projects. Libraries facilitate the transmission of knowledge by endorsing open access repositories, publishing platforms, and licencing

agreements. At the same time, they alleviate certain obstacles linked to conventional copyright laws. Open access, as mentioned by Suber (2012), encourages academic creativity and teamwork by making scholarly content freely available and unrestrictedly used. Osborne (2017) did a study on copyright and intellectual property, and the findings demonstrated that copyright and intellectual property concerns are complex difficulties for libraries, necessitating continual attention and adaptation to changing legal and technical landscapes. Libraries may negotiate these problems while achieving their role of supporting higher education teaching, research, and learning by embracing fair use principles, engaging with stakeholders, and pushing for open access.

2.5.9 Interoperability Challenges

Integrating various 4IR technologies into the library ecosystem can present interoperability problems. Ensuring seamless communication between various systems, databases, or apps is critical for creating a consistent user experience, but it can be technically challenging. Olubiyo (2024) also stated that the influence of changes brought about by the Fourth Industrial Revolution has been more noticeable in this decade. These developments are the result of modern technology, which will replace the human workforce with automation and robotics. Existing skills can no longer prepare graduates for this. In this context, graduates should be exposed to 4IR skills early on and trained for them. Scholars believe that technology advancements can lead to massive job destruction and may result in lower employment offers in various sectors, as well as changing the practice of jobs (Bahl, 2018).

As a result, Warren (2020, p.2) advises that because the 4IR disruptive shift is unavoidable, his practical suggestion for dealing with it is to "plan for the worst, hope for the best, and be opportunistic". According to the author, planning for the worst requires libraries to do crucial risk assessments, look further into future prospects and their inherent obstacles, and have a thorough awareness of the situation in order to make smart decisions to mitigate change. Hoping for the best involves taking a strategic positive approach in dealing with the uncertainties of the 4IR. Overall, academic libraries should endeavour to utilise all problems imposed by damaging technologies.

2.5.10 Job Displacement and Professional Ethics

Noh (2015) asserts that libraries are changing agents of the 4IR and warns that if they do not promptly improve themselves and their services, various issues, such as an alarming rate of

unemployment, would arise. It is also consistent with the findings of Gaspar, Juliao, and Cruz (2019), who identified job losses as a major concern for employees in the 4IR. Similarly, Frey and Osborne (2013) researched the future of employment and how sensitive jobs are to computerisation and discovered that there is a substantial probability of job loss as technological advances accelerate. These potential job concerns will clear in a later study by Frey et al. (2016), which demonstrate will be about 57% of jobs lost globally as a result of technological innovation

Frahm-Arp (2019) also stated that, even in this uncertain environment, libraries will continue to play an important role in the success of any university or research unit; thus, academic institutions must focus on how their libraries can be technologically equipped to enable active provision of relevant library services to information seekers. Liu (2011) agrees, stating that the implications of the 4IR with Lib 4.0 applications such as artificial intelligence and robotics should be viewed as complements to library services rather than threats.

Both Schwab (2016) and Anyim (2018) of Nigeria emphasised that the fear of losing jobs was the driving force behind the resistance to implementing some of the 4IR technologies. Hussain (2019) investigated how developing nations are addressing the difficulties and opportunities that libraries have acquired from the Fourth Industrial Revolution. The research revealed that workers believe that disruptive technologies will result in enormous job losses. This conclusion validates what was stated during the World Economic Forum (2016), which emphasised that the 4IR will result in job displacement and that skill shortages will heighten people' fear of losing their jobs.

Zervoudi (2020), confirmed these predictions, revealing that the fear of losing jobs owing to disruptive technology happened during enormous waves of technical progress in the nineteenth and twentieth centuries. Tella (2020a), on the other hand, determined that the 4IR will not result in job losses provided library professionals focus on learning how to use the latest technology to give best services. Frahm-Arp (2019), conducted research on how the 4IR is affecting jobs and how libraries in South Africa are dealing with the resulting issues. The study indicated that technologies such as Blockchain, big data, deep learning, and artificial intelligence will adopted where necessary to enhance library services and provide appropriate information to information seekers in the new technology trends.

2.5.11 Lack of Training and Professional Development Needs

To overcome the hurdles of implementing 4IR technologies, libraries must engage in training programmes and professional development opportunities for their staff. Building digital skills, instilling innovative attitudes, and encouraging continual learning are all critical to successfully integrating sophisticated technologies into library operations (Chiwere, 2007). The Fourth Industrial Revolution has enormous potential for converting university libraries into dynamic sites of innovation and information dissemination; yet, overcoming the problems listed above is critical to ensure a seamless transition to a tech-enabled future. According to Isah and Kayoma (2005), while nearly all libraries strive to provide users with the highest level of service, university libraries in developing countries face formidable difficulties in satisfying the needs of their users because they exist in a constantly changing environment in which threats to survival and growth are relatively common place.

According to Omagbemi (2017), leadership is still a hallmark of librarianship and higher education professionals, and that most of the leadership in the library profession is exercised by a small number of people. This indicates that unless more librarians take the initiative to modify how the profession is defined and practiced daily, librarians' skills will become obsolete, marginalising librarians' contributions to the academic enterprise. As Mercy (2023) point out, continual training programmes and opportunities for skill development are required to keep librarians up to date on developing technology and best practices in information management. Investing in the professional development of library staff allows institutions to better position themselves to fulfil the needs of customers in the digital age.

Kayembe and Nel (2019) stressed that programme trainers educate respondents on the 4IR, including its potential, challenges, and consequences if disregarded. This finding is congruent with Catalano et al.'s (2018) study, which evaluated academic libraries' engagement in 21st-century library trends. Results from ten libraries showed that staff retraining had a good influence, with 92% agreement. Furthermore, Chiware and Becker (2018) found that training improved research data management services in Southern Africa's response to change. Similarly, Sewell and Kingsley (2017) found that ongoing training will allow Cambridge University Library workers to thrive in the twenty-first century.

As Butler-Adam (2018) concisely stated, the emphasis should be on human factor development because a new technological skill set will be required to properly use the 4IR disruptive technologies. Ankrah and Atuase (2018) discovered in their studies on the use of electronic

resources among postgraduate students at the University of Cape Coast that the onus is on the academic library to keep to produce technological advancement; however, due to limited funds, most academic libraries in Africa are unable to train and retrain library staff to achieve the necessary skillset demanded by the 4IR.

The findings of both the studies by Ocholla and Ocholla (2020) and Manda and Dhaou (2019) emphasised that South African librarians cannot survive without ongoing training and retraining locally and internationally, with a focus on disruptive technologies and how they can be applied in the provision of library services. The authors also stated that it is the role of qualified academic librarians to educate library patrons through information literacy and workshops. Ghosh (2017) reacted on their views, stating that qualified librarians cannot be replaced by technology professionals, hence existing library staff should be trained and retrained. Frahm-Arp (2018) undertook a study on how the 4IR is changing jobs and how libraries in South Africa are coping with the inherent challenges. The study concluded that technologies such as Blockchain, big data, deep learning, and artificial intelligence have been implemented where necessary to enhance library services providing relevant information to information seekers in the new technological trends.

2.5.12 Lack of Staff Motivation

Employee engagement is critical in every organisation, including academic libraries (Ntlotlang, 2019). A study conducted by Bamgbose and Ladipo (2017) in a Nigerian academic library discovered that various forms of motivation, such as job security, wages and salary, relationships with colleagues, staff appraisal, financial incentives, and rewards, will available to library employees, and that the majority of the motivational parameters had a significant impact on their performance. An insufficient supply of these elements reduces librarians' behavioural intention to use new technologies. Devi, and Bhatt (2023) discovered that library staff at several selected public libraries in Botswana will demotivated and dissatisfied with their work. As a result, the staff lacked excitement for any project that would keep the library up to date with current trends. Demotivation was related to variables such as work security, poor interpersonal interactions, a lack of policies and procedures, incentives, and fringe benefits.

The findings are consistent with Lawson's (2018) research, which investigated the motivation and job satisfaction of staff members in Ghanaian academic libraries and discovered that motivation is a critical factor that drives library staff to work with enthusiasm and embrace

technological change. The study recommended that library administrators try to involve library personnel in the planning and deployment of any new Lib 4.0 technology or application. In line with these findings, Ntlotlang's (2019) study at Botswana International University of Science and Technology determined that it is vital to involve library workers from the start of any new technology installation.

The integration of technology is essential for modern libraries to remain relevant in an increasingly digital world. Motivated staff are more likely to embrace new technologies, seeking out opportunities to enhance library services through innovation (Okiki and Mabawonku, 2013). Conversely, a lack of motivation can hinder technology integration efforts. Research by Liu, and Sheng (2017) suggests that demotivated library staff may resist learning new technologies or fail to utilize existing ones effectively, impeding the library's ability to meet the evolving needs of patrons.

Libraries rely on active outreach and advocacy efforts to promote their services, attract new users, and secure funding and support from stakeholders. Motivated staff are instrumental in representing the library positively within the community and advocating for its importance. However, when staff motivation is lacking, outreach and advocacy efforts may suffer. According to a study by Siamuzwe (2012), demotivated library employees may lack the enthusiasm or energy to participate in outreach events or communicate the library's value effectively, resulting in decreased community engagement and support.

According to Gui (2017), continuous professional development is crucial for library staff to stay abreast of emerging trends, best practices, and innovations in the field. Motivated staff are more likely to pursue opportunities for training, networking, and skill development, enhancing their effectiveness as information professionals. Conversely, a lack of motivation can hinder professional growth. Research by Garcia and De la Vega (2018) suggests that unmotivated library employees may become complacent in their roles, resisting opportunities for learning and advancement, which can lead to stagnation and decreased quality of service. Staff turnover poses significant challenges for libraries, disrupting workflow, continuity of service, and institutional knowledge. Motivated staff are more likely to feel satisfied and fulfilled in their roles, reducing turnover rates. However, when staff motivation is lacking, retention becomes a concern. According to a study by Simpson (2017), low morale and job dissatisfaction are primary contributors to staff turnover in libraries, highlighting the critical link between motivation and employee retention.

While the studies emphasised the critical role of motivated library staff in embracing new technologies. The current literature focuses on general motivational factors but does not directly address how the introduction of cutting-edge technologies, characteristic of the 4IR, influences staff willingness to adopt and innovate within academic libraries in the region. Therefore, a deeper examination of how 4IR technologies impact both library services and staff motivation in Zambia is necessary to better understand the challenges and opportunities in this context.

2.6 Theories of Technology Adoption

The study's theories of technology adoption were founded on theories related to the effects of the Fourth Industrial Revolution (4IR), which enabled the development of research hypotheses. Therefore, the follow theories that explain the adoption of the 4IR on library services were identified and analysed, namely the Technology-Organisation-Environment (TOE) framework, the Technology Acceptance Model (TAM), and the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2).

2.6.1 *Technology-Organization-Environment*

The Technology-Organization-Environment Framework is a theoretical model used to understand how organizations adopt and implement technological innovations. It was developed by Tornatzky and Fleischer in 1990. The framework identifies three constructs that influence technology adoption:

2.6.1.1 *Technological Factors*

The Technological Factors within the Technology Organisation Environment (TOE) framework emphasize the influence of existing technologies, infrastructure, and the perceived benefits of adopting new technologies on organizations' decisions to adopt innovations. In the context of libraries, these factors include the technological readiness of library systems, the availability of advanced digital tools (such as cloud computing, AI-driven systems, and data analytics), and the technical skills required to operate and maintain these systems (Sahu & Thakur, 2020). The adoption of Fourth Industrial Revolution (4IR) technologies in libraries hinges on whether the existing technological infrastructure is compatible with these advanced tools. Libraries with outdated systems or insufficient technological support might find it challenging to integrate 4IR technologies such as automation, Internet of Things (IoT), and

machine learning into their operations. Therefore, libraries must assess their technological capabilities to ensure seamless adoption and integration of new innovations that align with 4IR principles (Khan et al., 2020).

Moreover, the speed at which libraries adopt 4IR technologies is influenced by the perceived advantages of these technologies in enhancing service delivery. Libraries that recognize the potential of technologies like artificial intelligence to automate routine tasks, offer personalized services, or improve resource management are more likely to embrace such advancements (Bawden & Robinson, 2020). However, this adoption process is also influenced by the technological trends in the broader environment, such as the development of digital learning tools and open-access platforms, which push libraries to innovate and adopt cutting-edge technologies (Choi & Lee, 2021). Additionally, libraries must consider the scalability of these technologies to ensure they can meet the growing needs of digital information and user demands. Therefore, technological factors within the TOE framework play a pivotal role in determining how quickly and effectively libraries can transition to 4IR technologies.

2.6.1.2 Organisational Factors

In the context of the Technology-Organisation-Environment (TOE) framework, organisational factors refer to the internal attributes of an organisation that influence the adoption and implementation of new technologies. For libraries navigating the Fourth Industrial Revolution (4IR), these factors include management support, organisational culture, and the availability of resources. A library's leadership plays a crucial role in setting the direction for adopting 4IR technologies, such as artificial intelligence, blockchain, and the Internet of Things (IoT). Support from management is vital for securing the necessary financial resources, training, and infrastructure to integrate these technologies (Oliveira & Martins, 2011). Additionally, the organisational culture, which includes the willingness to embrace innovation, directly impacts the pace and success of technology adoption (Venkatesh et al., 2003). In libraries, a culture that fosters continuous learning and adaptation is critical for effectively navigating the technological transformations characteristic of 4IR.

Furthermore, organisational resources, including skilled personnel, financial capital, and technological infrastructure, significantly influence 4IR technology adoption in libraries. Libraries with well-established IT departments and a robust infrastructure are better positioned to implement advanced technologies. However, challenges such as budget constraints and the need for ongoing staff training often hinder adoption, especially in smaller or under-resourced

libraries (Chong et al., 2015). The size and complexity of the library organisation also play a role, with larger institutions generally having more capacity to integrate and scale up 4IR technologies (Wamba et al., 2017). In this sense, libraries must leverage their internal resources and align them with strategic goals to ensure the successful adoption and utilisation of emerging technologies within the broader context of 4IR.

2.6.1.3 Environmental Factors

The Technology Organization-Environment (TOE) framework provides a comprehensive lens through which the adoption of technological innovations, such as those associated with the Fourth Industrial Revolution (4IR), can be understood in the context of libraries. In the TOE framework, environmental factors refer to the external influences that can either drive or hinder the adoption of new technologies. With 4IR technologies, such as artificial intelligence (AI), big data, and the Internet of Things (IoT), libraries are positioned to leverage these innovations to improve services, resource management, and user engagement. Environmental factors such as government policies, industry standards, and market competition are crucial in this process. Governments that prioritize digital transformation initiatives can create conducive environments through policies and funding that support library technology adoption. For example, national digital literacy programs or funding for library infrastructure improvements may directly influence the speed at which libraries integrate 4IR technologies (Bharadwaj et al., 2013).

Organizational factors, such as library staff skills, management support, and institutional readiness, are critical to adopting technologies that are central to the Fourth Industrial Revolution. For libraries, adopting 4IR technologies requires not only upgrading technological infrastructure but also ensuring that staff are adequately trained to operate and manage these innovations. Libraries with leadership that champions technological change and invests in continuous staff development are more likely to successfully implement advanced technologies. The alignment of the library's strategic goals with the capabilities of 4IR technologies also influences the adoption process (Davis, 1989). Organizational readiness, including the availability of resources for training and support, is essential in ensuring that the workforce can embrace the transformative changes brought by 4IR (Venkatesh et al., 2003).

From an environmental perspective, external factors such as the competitive pressures within the library sector and the broader information services market also affect technology adoption. In an era marked by digital transformation, libraries face increasing competition from private

sector information providers and digital platforms that offer similar services. The need to stay competitive in a fast-evolving information landscape can drive libraries to adopt 4IR technologies in order to enhance their operational efficiency, service delivery, and user engagement. Furthermore, collaboration between libraries and other external entities, such as universities, tech companies, and research institutions, can foster knowledge exchange and access to cutting-edge innovations. A collaborative environment facilitates shared learning and accelerates the implementation of advanced technologies (Tornatzky & Fleischer, 1990). Therefore, environmental factors, such as market dynamics and external partnerships, are key drivers of technology adoption in libraries.

2.6.2 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) has been widely utilised in examining the adoption of new technologies in various sectors, including education and library services (Opoku and Enu-Kwesi, 2019). In the context of assessing the effect of the Fourth Industrial Revolution on library services, TAM provided a robust framework for understanding how academic libraries in Lusaka Province adopted emerging technologies. By focusing on perceived ease of use and perceived usefulness, TAM helped to explain the factors influencing librarians' willingness to adopt technologies such as digital resources, automation, and artificial intelligence (Davis, 1989).

In particular, TAM allowed for the identification of barriers and enablers in technology adoption, facilitating a clearer understanding of how academic libraries evolved in response to the demands of the Fourth Industrial Revolution (Venkatesh & Davis, 2000). This theoretical model was particularly relevant in the study of academic libraries, as it captured both the technological and human factors affecting digital transformations in such environments. The key constructs from the Technology Acceptance Model (TAM), such as Perceived Usefulness (PU), Perceived Ease-of-Use (PEOU), attitude towards using, behavioural intention to use, and actual system use, provided a framework for understanding user adoption of these new technologies in library settings. These constructs helped in assessing how librarians perceived and engaged with innovative services brought about by the 4IR.

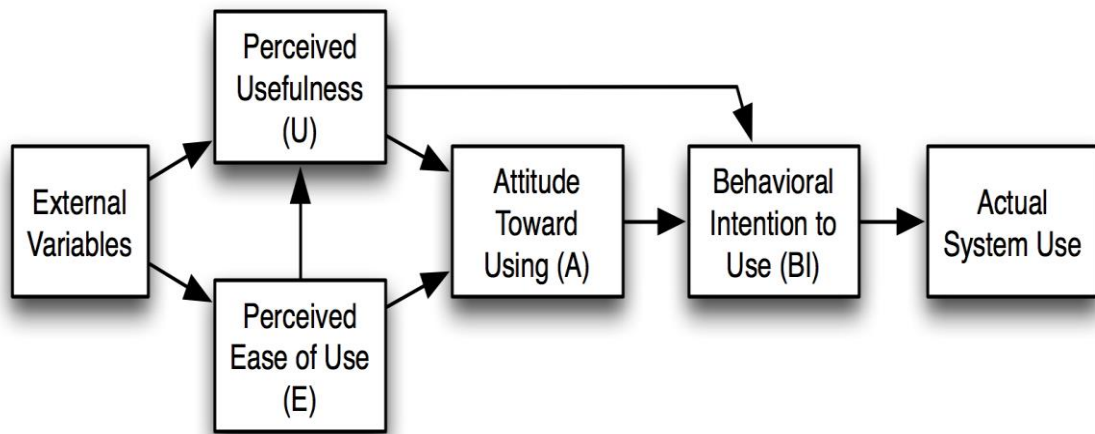


Figure 1: TAM structure (Davis et al. 1989)

2.6.2.1 Perceived Usefulness (PU)

Perceived Usefulness (PU) refers to the degree to which a person believes that using a particular system would enhance their job performance (Davis, 1989). In the context of library services, PU can be associated with how effectively digital libraries, automation tools, and AI-driven information retrieval systems meet users' needs. For instance, a study by Silver (2007) highlighted that users find digital library systems more useful when they provide quick and easy access to a vast array of resources, thereby improving their research productivity. Thus, integrating advanced technologies in libraries under the 4IR umbrella can significantly enhance their perceived usefulness among users.

2.6.2.2 Perceived Ease-of-Use (PEOU)

Perceived Ease-of-Use (PEOU) pertains to the degree to which a person believes that using a particular system would be free of effort (Davis, 1989). The adoption of 4IR technologies in libraries is heavily influenced by how easy these technologies are to use. For example, AI-driven cataloguing systems, user-friendly digital interfaces, and seamless access to online databases reduce the complexity for users, thereby increasing PEOU. Research by Venkatesh and Bala (2008) indicates that systems perceived as easy to use are more likely to be adopted and utilized effectively, which is crucial for libraries transitioning into the digital age.

2.6.3 Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)

The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) provides a robust framework for understanding user adoption of new technologies, particularly within the context of the Fourth Industrial Revolution (4IR). Venkatesh et al. (2012) extended the original UTAUT model by incorporating additional factors such as hedonic motivation, price value, and habit, making it suitable for assessing technology acceptance in academic libraries. As 4IR introduces innovations such as artificial intelligence (AI), machine learning, and blockchain, UTAUT2 can help analyse how librarians and users adapt to these technological advancements. The model's constructs including performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit are crucial in evaluating the extent to which library stakeholders adopt 4IR-driven services (Venkatesh et al., 2012).

Performance expectancy, the belief that a technology will improve performance, is a key factor in library technology adoption. With 4IR innovations, libraries are leveraging AI-driven chatbots, automated cataloguing, and predictive analytics to enhance efficiency (Chun et al., 2020). Librarians and users must perceive these advancements as beneficial for them to be widely accepted. Similarly, effort expectancy, which refers to the ease of technology use, plays a critical role in 4IR adoption. Libraries must ensure that new digital platforms are user-friendly and accessible to both staff and patrons (Joo et al., 2018). Training and digital literacy programs are essential for facilitating seamless integration of 4IR technologies into academic library services.

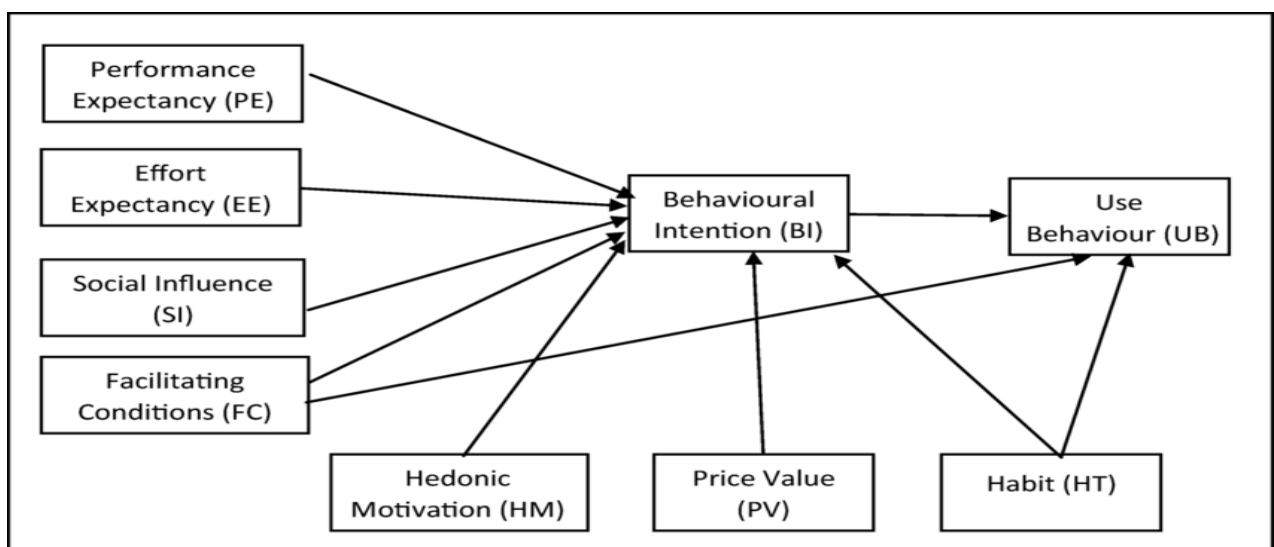


Figure 2: UTAUT2 structure (Venkatesh et al. 2003)

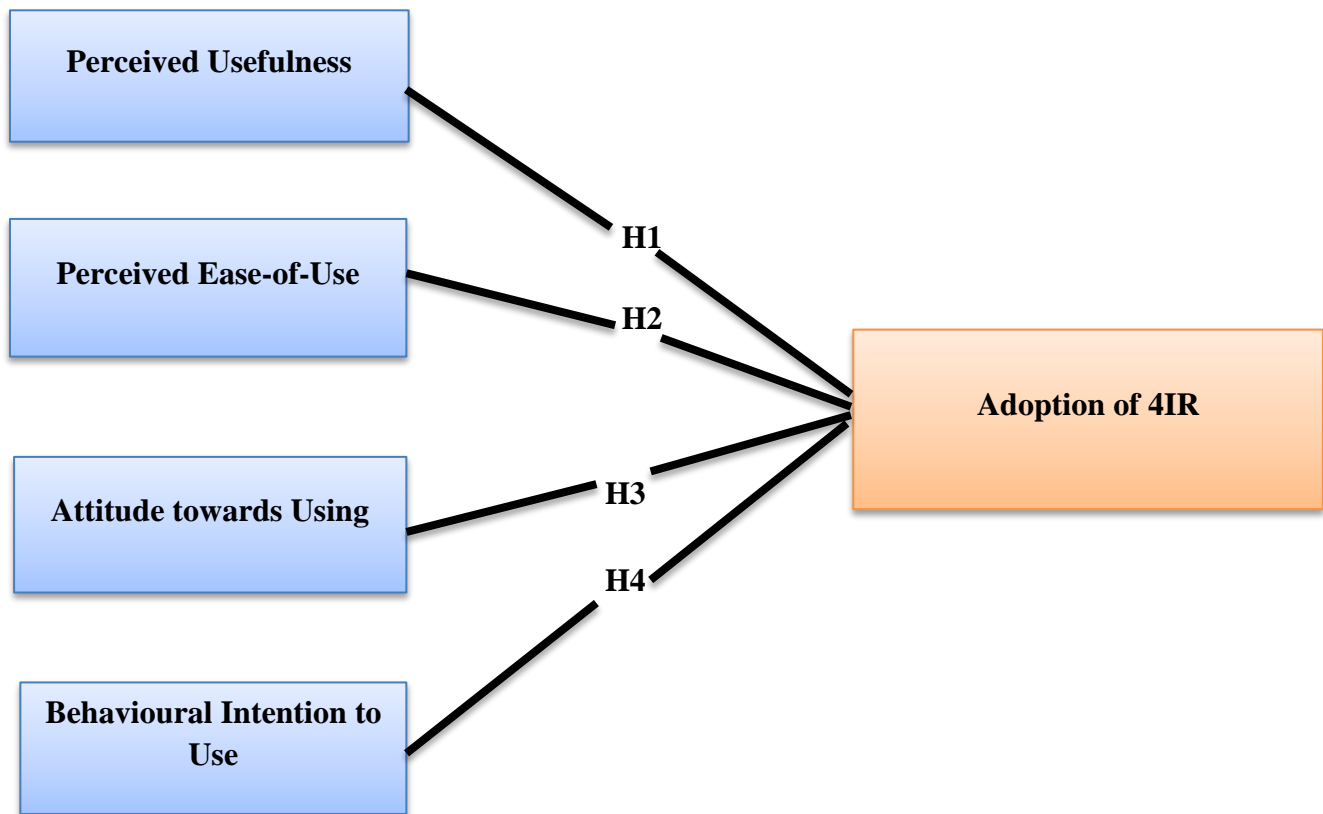
Social influence and facilitating conditions also significantly impact the adoption of 4IR technologies in libraries. Social influence, which refers to how users perceive the opinions of others regarding technology adoption, can drive acceptance when key stakeholders, such as university administrators and peers, advocate for emerging technologies (Venkatesh et al., 2012). Facilitating conditions, including the availability of technical support, infrastructure, and institutional policies, are crucial for ensuring successful implementation (Chang, 2021). Academic libraries must invest in adequate ICT infrastructure and skilled personnel to support 4IR-based services.

Hedonic motivation, price value, and habit further influence technology acceptance in academic libraries. Hedonic motivation, or the enjoyment derived from using a technology, can enhance engagement with interactive digital platforms, virtual reality-based learning resources, and AI-assisted research tools (Hamid et al., 2022). Meanwhile, price value how users perceive the cost-benefit ratio affects decisions regarding subscription-based digital libraries and data analytics tools (Venkatesh et al., 2012). Habit, referring to automatic technology use, becomes critical as academic institutions integrate 4IR technologies into daily library operations, ensuring continued adoption and usage

According to Venkatesh (2012), UTAUT2 provides a comprehensive model for analysing the adoption of 4IR technologies in academic libraries by assessing factors such as performance expectancy, effort expectancy, social influence, and hedonic motivation. Libraries must proactively address potential barriers to technology acceptance by offering adequate training, infrastructure, and policy support. As academic libraries transition into the digital era, leveraging UTAUT2 can help in evaluating and optimising 4IR-driven innovations for sustainable service delivery. Future studies should explore empirical applications of UTAUT2 in different academic library settings to further validate its relevance in this technological landscape.

2.7 Proposed Model and Hypotheses for the Study

After analysing the three theories and models relating to the effect of the 4IR on library services, it has become apparently clear that there are factors that influence the effect of any technology. These factors act as independent and dependent variables



Proposed Model for the Adoption of the 4IR in Zambia

2.8 Gaps in the Literature Reviewed

Kari (2014) posited that research on the effect of the Fourth Industrial Revolution (4IR) on library services in academic settings has grown substantially in recent years, with many studies focusing on developed countries. However, there is a noticeable dearth of literature examining this phenomenon in developing countries, particularly in the context of Zambia. While studies such as those by Devi and Bhatt (2023) and Tan and Ng (2020) have explored the role of emerging technologies in transforming library services, they primarily concentrate on Western contexts. Furthermore, the few existing studies on African countries often provide a broad overview of technological adoption in libraries without delving into the specific challenges and opportunities presented by 4IR. Consequently, there is a significant research gap in understanding how academic libraries in Zambia are adapting to 4IR and what unique factors shape their responses.

Moreover, existing literature tends to focus on the technological aspects of 4IR, overlooking its broader socio-economic implications for library services. A study by Hussain (2019) highlight the transformative potential of technologies such as artificial intelligence and big data analytics, they often neglect to address how these advancements intersect with socio-cultural

factors within the Zambian context. For instance, the socio-economic disparities and infrastructural challenges prevalent in Zambia may influence the adoption and implementation of 4IR technologies in academic libraries differently than in developed nations. Therefore, there is a pressing need for research that goes beyond the technological aspects of 4IR and examines its socio-economic dimensions in the context of library services in Zambia (Chisenga, 2021). Such research can provide valuable insights into how academic libraries can effectively leverage 4IR technologies while addressing the unique challenges they face in a developing country setting.

While there has been significant attention on the theoretical implications of the 4IR on library services, there remains a noticeable gap in empirical research regarding the actual implementation of 4IR technologies in academic libraries in Zambia. Although some studies discuss the potential benefits of technologies such as artificial intelligence, cloud computing, and big data analytics for library services, little is known about how these technologies are being practically integrated into the daily operations of Zambian libraries. Further research could explore the challenges academic libraries face in adopting these technologies, the types of infrastructure investments required, and the extent to which library staff are trained to effectively use and manage these tools.

Impact of the Digital Divide on 4IR Adoption in Zambian Libraries: The digital divide remains a significant concern in Zambia, where many regions still face challenges in accessing reliable internet and digital resources. While studies have highlighted this issue globally, specific research on how the digital divide impacts the adoption of 4IR in academic libraries within Zambia is scarce. Exploring the extent to which this divide affects the ability of libraries to provide equitable access to digital resources and services would offer valuable insights. Additionally, research could investigate how libraries can bridge this gap, ensuring that both urban and rural students have equal opportunities to benefit from the advancements brought by the Fourth Industrial Revolution.

2.7 Summary of the Chapter

This chapter reviewed the relevant literature on the effect of the Fourth Industrial Revolution (4IR) on academic library services. The literature reflects ongoing discussions about the Fourth Industrial Revolution and its underlying disruptive developments. These developments have impacted practically every aspect of society, but their effect on libraries has been particularly striking. While some authors view the 4IR's disruptive technologies as a challenge to libraries,

others see them as an opportunity to enhance and improve existing services. As the literature indicates, libraries are well aware that they are not only contending with traditional competitors, such as search engines like Google, in the provision of information, but also with the disruptive changes brought by the 4IR, which has the potential to render the role of the librarian irrelevant.

Internationally, libraries have taken steps to keep up with 4IR technology and applications, as well as to train librarians in their use. However, African underdeveloped countries, such as Zambia, have been slower to adopt these disruptive technologies. The literature also found that academic librarians require training to bridge important gaps in skills, competencies, and abilities, as well as policies to mitigate and embrace the disruptive consequences of 4IR technologies and applications. Academic libraries face critical challenges such as inadequate funding, ICT infrastructure, institutional support, and policies. Although academic librarians' attitudes of resistance to change and fear of job loss have been documented, strategic actions taken by libraries towards 4IR prioritize the provision of ICT infrastructure, the development of technologies, training, job motivation, innovation strategies, policies on emerging technologies, and budgetary allocation. The next chapter discusses the research design and methodology of the study

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Overview

This chapter presented the systematic processes and methods used to investigate the effect of the Fourth Industrial Revolution on academic library services. The chapter was organised into the following subsections: philosophical assumptions, research design, data collection instruments, testing of instruments, reliability and validity of the study, study population, sampling and sampling techniques, data collection, data analysis, limitations of the study, and a chapter summary.

3.1 Philosophical Assumptions

In assessing the effect of the 4IR on library services in academic libraries, ontology and epistemology provided essential philosophical foundations. Ontologically, the study acknowledged the realist perspective on 4IR technologies, such as artificial intelligence and digital automation, were transforming the nature of library services. This ontological stance viewed these technological advancements as objectively existing phenomena to which libraries had to adapt in order to remain relevant (Bryman, 2016). The epistemological stance on assessing the effect of the 4IR on library services involved examining how knowledge is created, accessed, and disseminated in the digital age. This perspective considers the transformative impact of technologies like artificial intelligence, big data, and automation on traditional library practices.

The philosophical design for this study was influenced by positivism, a social paradigm. August Comte developed this epistemology in the late nineteenth century. Comte and other positivists argued that observation and reason were scientific methods for understanding human behaviour; true knowledge was based on sensory experience and could be achieved through observation and experimentation (Howell, 2013). This suggested that social inquiry could be conducted objectively and scientifically to yield empirical data. Positivists believed that any scientific investigation should adhere to four principles.

- (i) **Determinism:** Suggests that external factors cause events, which is why it's important to comprehend these causal relationships in order to forecast and manage events;

- (ii) **Empiricism:** It is the accumulation of verifiable empirical evidence to support theories or hypotheses.
- (iii) **Generality:** the process of generalising the observation of the particular phenomenon to the world at large.
- (iv) **Parsimony:** It refers to explaining things as economically as feasible.

The adoption of positivism in assessing the effect of the Fourth Industrial Revolution (4IR) on library services in academic libraries focused on the objective measurement and analysis of observable phenomena. Positivism, with its emphasis on empirical evidence and quantitative methods, allowed researchers to systematically evaluate the effects of 4IR technologies, such as artificial intelligence, big data, and the Internet of Things, on library operations and services. For instance, studies showed that the integration of these technologies enhanced the efficiency of information retrieval systems, improved user experience, and streamlined library management processes (Manjunatha, 2023). By employing positivist methodologies, such as surveys and statistical analysis, the researchers generated robust data that provided insights into how these technological advancements were transforming academic libraries, thereby offering evidence-based recommendations for future developments.

3.2 Research Approach

There are two primary research approaches: deductive and inductive. The deductive approach was used to establish hypotheses based on a pre-existing theory, and then a research strategy was devised to test them. Inductive reasoning, on the other hand, allowed for the development of a theory rather than the adoption of an existing one, as was the case with the deductive approach. According to Snieder and Larner (2010), the deductive method was well-suited to the positivist approach, which involved forming hypotheses and statistically testing the expected results to an acceptable degree of probability. Given that the study aimed not only to document the adoption of the Fourth Industrial Revolution but also to test hypotheses about its effect on library services in Zambia, the study employed a deductive method. Given the deductive approach and positivist philosophy used, it was appropriate to classify this study as quantitative and descriptive survey research.

3.3 Research Design

The study adopted a quantitative design to assess the effect of the 4IR on library services in academic institutions. This approach enabled the identification of patterns, relationships, and

trends across large sample populations, allowing the researcher to evaluate the extent of 4IR's impact on various academic libraries. The use of surveys, structured questionnaires, and numerical data facilitated the quantification of changes in technology adoption, service delivery, and user satisfaction. As emphasized by Creswell (2014), quantitative research was particularly effective in measuring and analysing variables to understand widespread phenomena such as technological transformations in academic settings.

3.4 Study Sites

The study was conducted in Lusaka Province among academic libraries that are registered with the Higher Education Authority Act of 2021 (HEA). Lusaka Province, the capital region of Zambia, is home to several prominent academic libraries that serve as crucial hubs for education and research. These academic libraries provide access to specialised materials for their diverse student bodies (Higher Education Authority, 2021). They not only facilitate academic pursuits but also contribute to the intellectual and cultural development of Lusaka Province.

3.5 Study Population and Sample Size

The study population refers to the specific group of individuals or entities that a researcher is interested in studying and from whom data is collected to address the research questions (Neuman, (2014). The selection of a study population is critical, as it directly impacts the generalizability and validity of the research findings. For example, in clinical research, the study population might include patients with a particular disease, ensuring that the results apply to that group. In this case, the study population consisted of librarians from all academic libraries in both public and private universities in Lusaka Province that were registered with the Higher Education Authority Act of 2021 (HEA).

The study selected 34 academic libraries from universities registered with the Higher Education Authority (HEA) as the study population to assess the effects of the Fourth Industrial Revolution (4IR) on library services in Lusaka Province. This was pivotal because librarians played an integral role in shaping and implementing these services. Librarians were at the forefront of adapting traditional library functions to incorporate technological advancements brought about by the 4IR, such as artificial intelligence, big data analytics, and digital repositories (Simpson, 2017).

Table: 2. Census Survey of Academic Libraries by HEA

N0	NAME OF THE INSTITUTION	TOTAL NUMBER OF LIBRARIANS
1	Africa Research University	3
2	African Christian University	2
3	Ambassador International University	2
4	Blessings University of Excellence	2
5	Brook Besor University	2
6	Cavendish University	4
7	Chalimbana University	3
8	Chreso University	6
9	City University of Science and Technology	4
10	Eden University	5
11	Gideon Robert University	3
12	Greenlight University	2
13	Harvest University	2
14	Information and Communication University	3
15	Justo Mwale University	3
17	Kenneth Kaunda Metropolitan University	2
16	Ley Mwanawasa Medical University	8
18	Livingstone International University of Tourism Excellence and Business Management (LIUTEBM)	2
19	Lusaka Apex Medical University	7
20	Mansfield University	2
21	Oak University	2
22	Rockview University	4
23	St. Bonaventure University	3
24	Sunningdale University	2
25	Supershine University	2
26	Texila American University	3
27	The University of Zambia	37
28	Trinity University	2
29	Twin Palm Leadership University	2

30	UNICAF (Zambia Limited) University	3
31	University of Africa	3
32	University of Lusaka	12
33	Zambian Open University	11
34	ZCAS University	4
TOTAL		155

3.6 Sampling Techniques

Bryman and Bell (2015) stated that “sampling is the process of selecting a subset of cases from a larger population” (p. 187). The choice of sampling technique depended on various factors, such as the nature of the study, the characteristics of the population, and the specific research objectives. Therefore, the study employed a stratified random sampling technique to determine both the sample size and the respondents who would represent the entire population.

Stratified random sampling involved dividing the population of respondents into different strata or subgroups based on specific characteristics, such as library size, type (public or private), or the level of technological integration. Simple random sampling was then used within these strata to select individual participants, ensuring that every member within each group had an equal chance of being included. This approach enhanced the study’s reliability by capturing diverse viewpoints on how emerging technologies are transforming library services in the region. The sample population for this study consisted of two categories: Librarians from Public Universities and Private Universities in Lusaka Province.

3.7 Data collection Instruments

The study collected data using a standard questionnaire with closed-ended questions. Babbie and Mouton (2001) stated that closed-ended questions helped respondents better understand the meaning of the questions. These questions could be answered within the same framework, allowing responses to be compared more effectively. Additionally, answers were easier to code and statistically analyse, and response choices helped clarify the meaning of the questions for respondents. The questionnaire was designed and compiled in such a way that it gathered information relevant to answering the research questions. Hence, it consisted only of important questions aimed at obtaining the necessary information to address the study’s objectives.

The questionnaire was structured into four subsections. The first section focused on personal information; the second section focused on academic libraries adopting Fourth Industrial Revolution technologies within their library services; the third section examined how the Fourth Industrial Revolution influenced information access and retrieval methods in academic libraries; the fourth section addressed the skills and training requirements of library staff in response to the Fourth Industrial Revolution; and the final section discussed the challenges academic libraries faced in adopting Fourth Industrial Revolution technologies in their library services.

3.8 Reliability and Validity of the Study

3.8.1 Reliability

The degree to which a measure of a construct is consistent and dependable is commonly referred to as reliability. According to Leedy and Ormrod (2005), reliability is defined as the consistency with which a measuring instrument produces particular results when the entity being measured remains the same. To ensure consistency, several initiatives were implemented for the data collection instrument. The researcher initially tested the questionnaires to check if the results would be consistent. The supervisor played a crucial role in ensuring the consistency of the results. The data collection instruments were also pilot-tested.

3.8.2 Validity

According to Creswell (2018), validity refers to a researcher's ability to draw justifiable and meaningful conclusions from scores related to a sample or population. The items for the questionnaire were derived from the reviewed literature. In the current study, large, representative samples of the population were used. The goals of the ongoing review were explained to ensure solid outcomes. The researcher created questionnaires with clear, easy-to-understand questions and language that all respondents could comprehend.

3.8.3 Triangulation

Triangulation as a quantitative design was valuable in studying the effect of the 4IR on library services in academic libraries because it allowed for a comprehensive and validated analysis by combining multiple data sources, methods, or perspectives. By integrating quantitative data from surveys, usage statistics, and technological adoption rates, triangulation provided a more robust understanding of how 4IR technologies such as AI, automation, and digital resources

influenced library operations and user engagement. This approach minimised bias, enhanced the reliability of findings, and offered a well-rounded view of the transformational effect of 4IR on academic libraries.

3.9 Data Collection Procedure and Timeline

The data collection exercise was carried out according to the schedule outlined in the research proposal. The questionnaires were distributed to respondents in the research area for completion.

3.10 Data Analysis

The collected data, which was quantitative was analysed using both descriptive and inferential statistics. Initially, the data was checked for gaps and inconsistencies. Next, the questions were coded, and responses were assigned numbers in preparation for data entry. During the coding process, the responses to closed-ended questions were grouped into categories, and numbers were assigned to these categories. Once coding was completed, the data was entered into SPSS Version 22 and analysed, with descriptive statistics generated for various questions. Given that the study was quantitative in design and a stratified random sampling method was employed, the Chi-square test of independence was used to determine whether there was a relationship between the identified independent variables and the dependent variable. In this context, the following hypotheses were tested at a 0.05 level of significance, as shown below.

Table 3: Hypotheses Testing Using Chi-square Test of Independence on TAM Constructs

Null Hypothesis (H ₀)	Alternative Hypothesis (H ₁)
Perceived Usefulness	
H₀: There is no significant relationship between the perceived usefulness of 4IR technologies and their adoption in academic libraries.	H₁: There is a significant relationship between the perceived usefulness of 4IR technologies and their adoption in academic libraries.
Perceived Ease-of-Use (PEOU)	
H₀: There is no significant relationship between the adoption of 4IR technology and the ease of use in academic libraries.	H₁: There is a significant relationship between the adoption of 4IR technology and the ease of use in academic libraries.

Attitude towards Using	
H₀: There is no significant relationship between the adoption of 4IR technology and attitudes towards Using	H₁: There is a significant relationship between the adoption of 4IR technology and attitude towards using
Behavioural Intention to Use	
H₀: There is no significant relationship between the adoption of 4IR technology and behavioural intention to use	H₁: There is a significant relationship between the adoption of 4IR technology and behavioural intention to use

Furthermore, the normality of the sampled population was tested using the one-sample Kolmogorov-Smirnov and Shapiro-Wilk tests at a 0.05 level of significance. These tests were used to determine whether a sample came from a specific distribution (Real Statistics, 2021). Both the Kolmogorov-Smirnov and Shapiro-Wilk tests are non-parametric tests that assess whether a sample is drawn from a population that follows a normal distribution. The age variable, being numeric, was used in these tests.

Table 4: Normality Testing Using Kolmogorov-Smirnov and Shapiro-Wilk Tests

Null Hypothesis	Alternative Hypothesis
H₀: The Sampled population is not normally distributed	H₁: The Sampled population is normally distributed

3.11 Ethical Considerations

The researcher aimed to ensure ethical compliance throughout the study. This involved obtaining permission from academic libraries in selected universities before distributing questionnaires to respondents. Additionally, individuals only participated in the study after providing informed consent and voluntary. This meant that respondents received a cover letter explaining the study's objectives alongside the research tools, giving them the choice to opt in or out of the study.

In this study, respondents were not required to disclose their real identities on the questionnaires to maintain anonymity. The collected data was kept confidential and solely used for the study's purposes. The researcher assured that no unauthorised individuals would have access to the data. Respondents' safety was guaranteed as the study was non-experimental. Data interpretation and presentation were conducted honestly and without bias toward the researcher's opinions.

3.12 Summary of Chapter Three

This chapter outlines the systematic processes and methodologies employed in investigating the impact of the 4IR on academic library services. It begins with the philosophical assumptions underlying the study, which draw on ontological and epistemological perspectives, specifically realism and positivism. The study adopts a positivist approach, focusing on empirical evidence and objective measurement to assess how 4IR technologies like artificial intelligence, big data, and automation influence academic libraries. The research design is quantitative, using structured surveys to gather data and identify patterns in technology adoption, service delivery, and user satisfaction. By applying a deductive approach, the study tests hypotheses about the effects of 4IR on library services in Lusaka Province, Zambia.

The study is conducted to 120 librarians in Lusaka Province, Zambia, selected from both public and private universities registered with the Higher Education Authority Act of 2021. The population consists of librarians who play a pivotal role in the adoption and integration of 4IR technologies into library services. Stratified random sampling was employed to ensure that diverse viewpoints from libraries of various types and sizes were represented. The data collection instrument used was a structured questionnaire, designed to gather specific information on the adoption of 4IR technologies, their impact on library services, and the skills required by librarians to manage these advancements. The reliability and validity of the study were ensured through pilot testing, triangulation, and careful questionnaire design.

Data analysis involved the use of both descriptive and inferential statistics, with SPSS software applied to analyse the collected data. Chi-square tests were used to explore relationships between variables, testing hypotheses related to the effect of 4IR on library services. Ethical considerations were prioritized, with informed consent obtained from participants, and confidentiality ensured throughout the study.

CHAPTER FOUR: PRESENTATION OF RESEARCH FINDINGS

4.0 Overview

This chapter presented the research findings, beginning with a description of the response rate and the characteristics of the respondents. Thereafter, the responses obtained from librarians through a questionnaire were analysed quantitatively using descriptive statistics. The study utilised the Statistical Package for Social Science (SPSS) Version 25, supported by Microsoft Excel 202, to present data in graphic, and tabular. The Chi-square test of independence was employed to investigate the relationships among variables to underpin the study's major findings. The analysis and presentation of results were organised under sub-headings aligned directly with the research questions.

1. To what extent have academic libraries adopted the Fourth Industrial Revolution technologies within their library services?
2. How has the Fourth Industrial Revolution influenced information access and retrieval methods in academic libraries, such as the adoption of online databases, and digital repositories?
3. What are the skills and training requirements of library staff in response to the Fourth Industrial Revolution?
4. What challenges do academic libraries face in the adopting the Fourth Industrial Revolution technologies in their library services?

4.1 Response Rate

In this study, a total of 112 questionnaires were administered to librarians. Out of the 112, 106 questionnaires were filled out and returned, representing a 95% response rate. This was a positive sign that the majority of the research respondents were eager to participate in the study, as the researcher was able to go through the questionnaire with the respondents before leaving it.

Table 5: Questionnaire return

Category of Respondents	Questionnaires Distributed	Questionnaires Returned	Questionnaires Unreturned	Response Rate
Academic Librarians	112	106	6	95%

4.2 Distribution of the Sample Population

As shown in Table 6, the distribution of the sampled population was normal according to the Kolmogorov-Smirnov test, and tests on the variable age also demonstrate normality. The p-value obtained in this test was .000, which is far lower than the 0.05 significance level stated in Table 6. Therefore, the null hypothesis, which stated that the sampled population was not normally distributed, was rejected. This indicates that the data was normally distributed.

Table 6: Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Age	.234	106	.000	.837	106	.000

a. Lilliefors Significance Correction

4.3 Demographic Characteristics of the Respondents

4.3.1 Gender Distribution

To assess the proportion of male and female academic librarians in selected universities, the frequency of gender was calculated. The study revealed that 63 (60%) were female and 43 (40%) were male. These findings highlighted that female librarians were more prevalent in this academic setting.

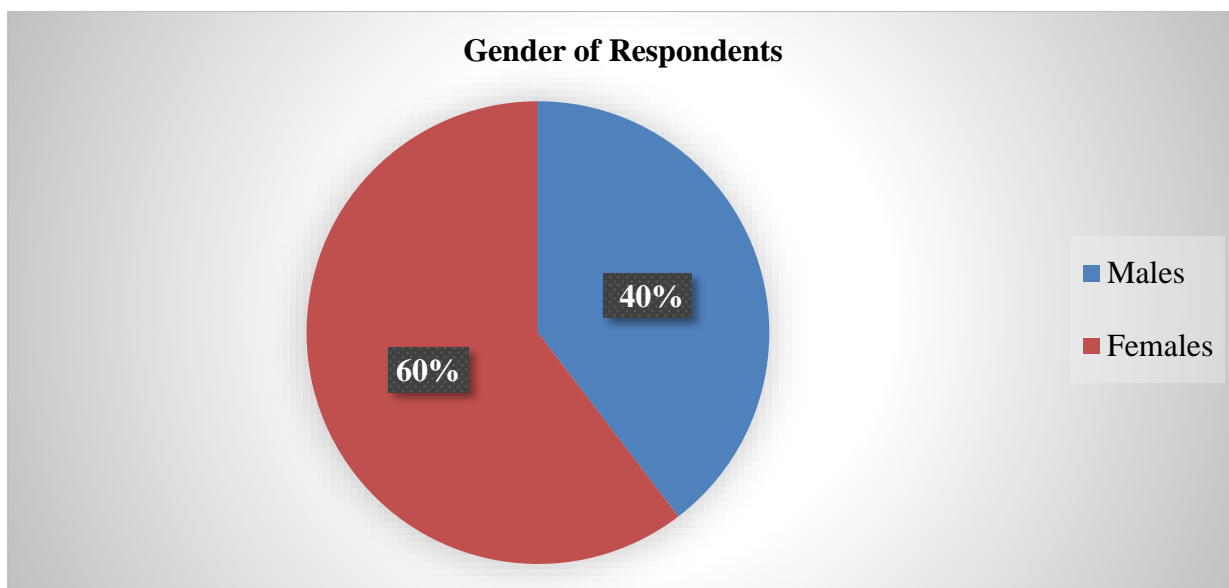


Figure 3: Gender of Respondents

4.3.2 Age of Respondents

Age played a vital role in determining outcomes or influencing findings in the research. Out of 106 academic librarians in Lusaka Province, 7 (6.6%) were aged 20-26 years, 27 (25.5%) were aged 27-29 years, 16 (15.1%) were aged 30-34 years, 16 (15.1%) were aged 35-39 years, and the majority 40 (37.7%) were 40 years and above. These results suggested that a significant portion of the librarian population likely had substantial experience and potentially higher levels of expertise, which could have influenced library services and management practices.

Table 7: Age of Respondents

		Frequency	Percent
Valid	20-24 years	7	6.6
	25-29 years	27	25.5
	30-34 years	16	15.1
	35 -39 years	16	15.1
	40 years and above	40	37.7
	Total	106	100.0%

4.3.3 Respondents' Position at Work

The results presented in Table 8 illustrated the distribution of positions held by 106 librarians within a specific organisation. Among these, 35 (33%), indicating that this role was the most common within the library setting. The next largest group consisted of assistant librarians 22 (20.8%), followed closely by senior library assistants 17 (16%). Chief librarians and deputy librarians represented a smaller fraction of the workforce, with only 11 (10.4%) and 2 (1.9%) respectively, suggesting that higher managerial roles were less prevalent among this group. Additionally, library assistants comprised 19 (17.9%), reflecting a significant support role within the library structure. This distribution highlighted a hierarchical structure where operational roles such as librarians and assistants dominated, while leadership positions were limited.

Table 8: Position at Work

		Frequency	Percent
Valid	Chief librarian	11	10.4
	Deputy librarian	2	1.9
	Librarian	35	33
	Assistant librarian	22	20.8
	Senior library assistant	17	16
	Library assistant	19	17.9
	Total	106	100.0%

4.3.4 Highest level of education

In Table 9 below, out of the total number of respondents, 6 (5.7%) were certificate holders, 24 (22.6%) were diploma holders, the majority 47 (44.3%) were bachelors' degree holders, 27 (25.5%) were master's degree holders, and 2 (1.9%) had doctoral degrees. This distribution suggested a relatively high level of educational attainment among the respondents, with most having degrees or higher qualifications.

Table 9: Highest level of education

		Frequency	Percent
Valid	Certificate	6	5.7
	Diploma	24	22.6
	Bachelor's degree	47	44.3
	Master's degree	27	25.5
	Doctoral degree	2	1.9
	Total	106	100.0%

4.3.5 Respondents' Working Experience

As depicted in Figure 4 below, respondents were asked to indicate their years of work experience. A total of 38 respondents (36%) reported having 9 years or more, 8 (8%) indicated 5–8 years, 37 (35%) reported 1–4 years, and 23 (22%) stated less than 1 year. This distribution suggested a workforce skewed towards experienced professionals, while still accommodating a notable number of less experienced individuals.

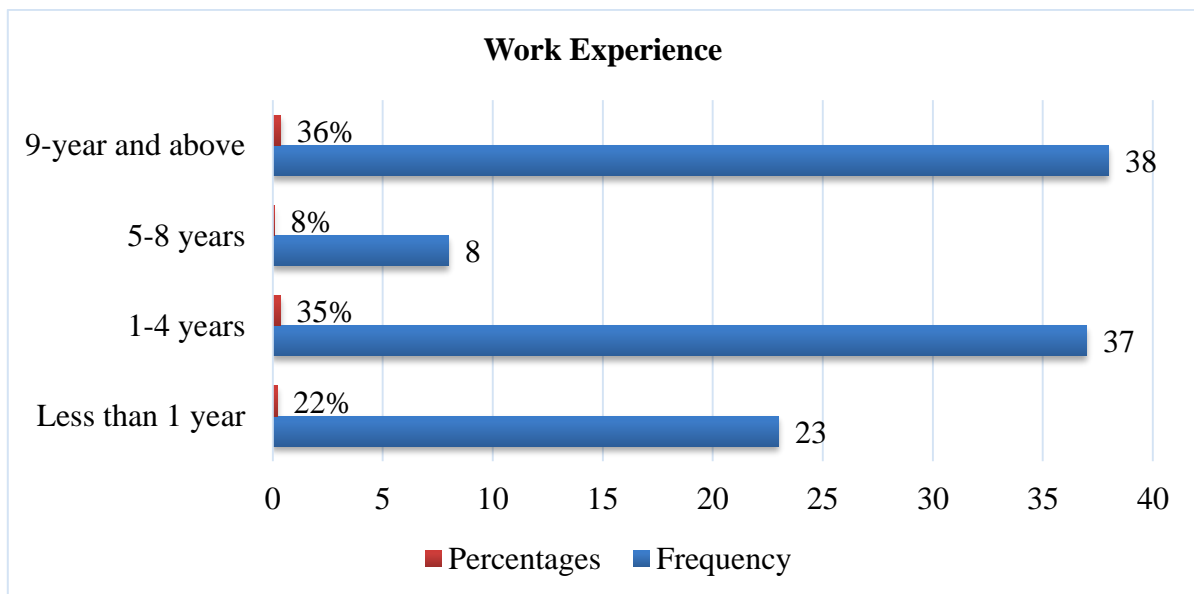


Figure 4: Work experience

4.3.6 Respondents Working Departments

As portrayed in Table 10 below, the respondents were asked to identify the department they worked in. Out of the total sample, the majority 26 (24.5%) worked in the department of reference services, 9 (8.5%) in electronic resources, 13 (12.3%) in the IT support unit, 17 (16%) in the cataloguing department, 10 (9.4%) in the acquisition department, 7 (6.6%) in the institutional repository, and 9 (8.5%) in administration. These findings revealed that the department of reference services had the highest representation among respondents, indicating a strong emphasis on direct user assistance and information retrieval.

Table 10: Working Department

		Frequency	Percent
Valid	Reference services	26	24.5
	Electronic resources	9	8.5
	IT support unit	13	12.3
	Cataloguing	17	16.0
	Circulation	15	14.2
	Acquisition	10	9.4
	Institutional repository	7	6.6
	Administration	9	8.5
	Total	106	100.0%

4.3.7 Rating the level of Institutional Repository Adoption in Libraries

In Figure 5 below, the respondents were asked to rate the level of Institutional repository adoption in their libraries. The results showed that 11 respondents (10%) rated it as very high, 38 (36%) rated it as high, the majority 49 (46%) rated it as moderate, and 8 (8%) rated it as low. These findings suggested that most respondents had perceived the level of technological adoption in their libraries as moderate or high.

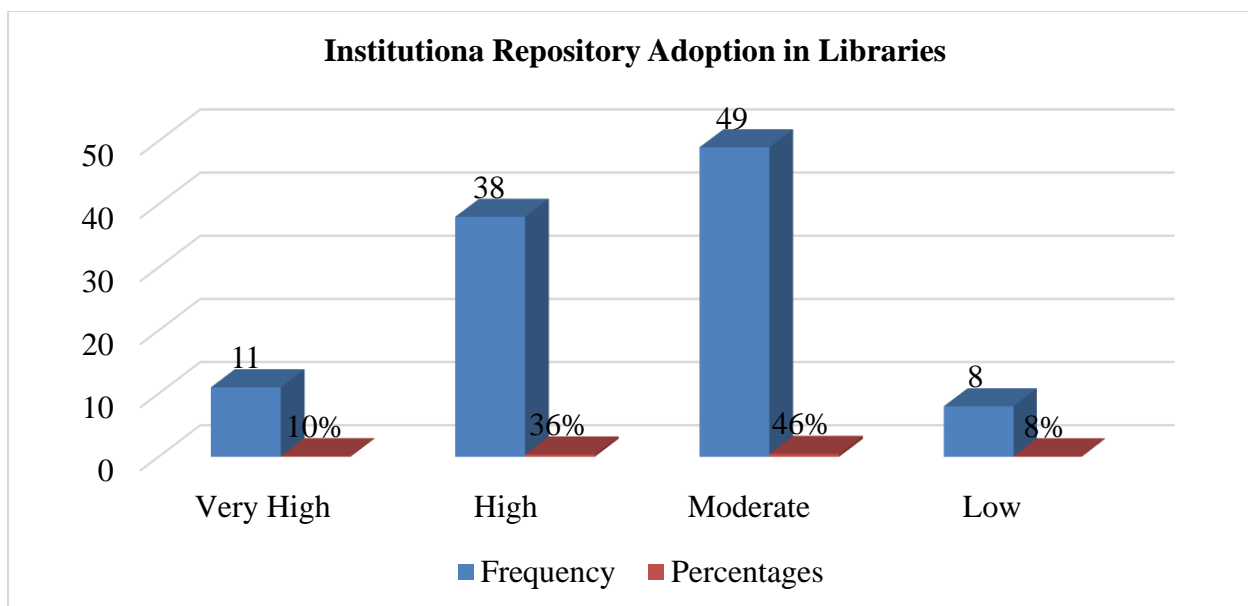


Figure 5: Institutional repository adoption in libraries

4.4 Academic Libraries Adopting the Fourth Industrial Revolution Technologies within Library Services.

4.4.1 Awareness of the Fourth Industrial Revolution (4IR)

Table 11 below, respondents were asked how they had become aware of the 4IR. The study found that 16 respondents (15.1%) had learned about it during an information literacy training program, 19 (17.9%) through research work, the majority 41 (38.7%) via the internet, 17 (16%) through social media platforms, 4 (3.8%) from the university website, 4 (3.8%) through staff meetings, and 5 (4.7%) at a conference or seminar. The findings indicated that the internet was the primary source of information about the Fourth Industrial Revolution, with respondents having learned about it through online searches, highlighting the internet's role in disseminating emerging knowledge.

Table 11: Awareness of the Fourth Industrial Revolution

		Frequency	Percent
Valid	During information literacy training programme	16	15.1
	Research work	19	17.9
	Internet	41	38.7
	Social media platforms	17	16.0
	University website	4	3.8
	Staff meeting	4	3.8
	Conference / Seminar	5	4.7
	Total	106	100.0%

4.4.2 Fourth Industrial Technologies and Applications are Available in Library

As depicted in Table 12, below, respondents were asked to identify the new Library 4.0 (LIB4.0) technologies and applications that were available in their libraries due to the Fourth Industrial Revolution. The study revealed the following results: 20 respondents (18.9%) indicated artificial intelligence, 3 (2.8%) mentioned big data tools, 5 (4.7%) noted a robot library assistant, 2 (1.9%) cited blockchain technology, 13 (12.3%) referred to the Internet of Things (IoT), the majority 30 (28.3%) said digital library repositories, 15 (14.2%) mentioned a library social media platform, 7 (6.6%) indicated reference management tools, 4 (3.8%) referred to 3D modeling software, 2 (1.9%) cited a chatbot, and 5 (4.7%) mentioned a circulation module. The study's findings highlighted that digital library repositories and artificial intelligence were the tools most commonly adopted in libraries, suggesting that libraries prioritised digital accessibility and advanced data processing to enhance user experience and operational efficiency.

Table 12: Technologies and Applications are Available in Libraries

		Frequency	Percent
Valid	Artificial intelligence	20	18.9
	Big data tools	3	2.8
	Robot library assistant	5	4.7
	Blockchain technology	2	1.9
	Internet of Things (IoT)	13	12.3
	Digital library repositories	30	28.3
	Library social media platform	15	14.2
	Reference management tools	7	6.6
	3D modelling software	4	3.8
	Chatbot	2	1.9
	Circulation module	5	4.7
	Total	106	100.0%

4.4.3 Implementing Artificial Intelligence (AI) for Cataloguing and Indexing

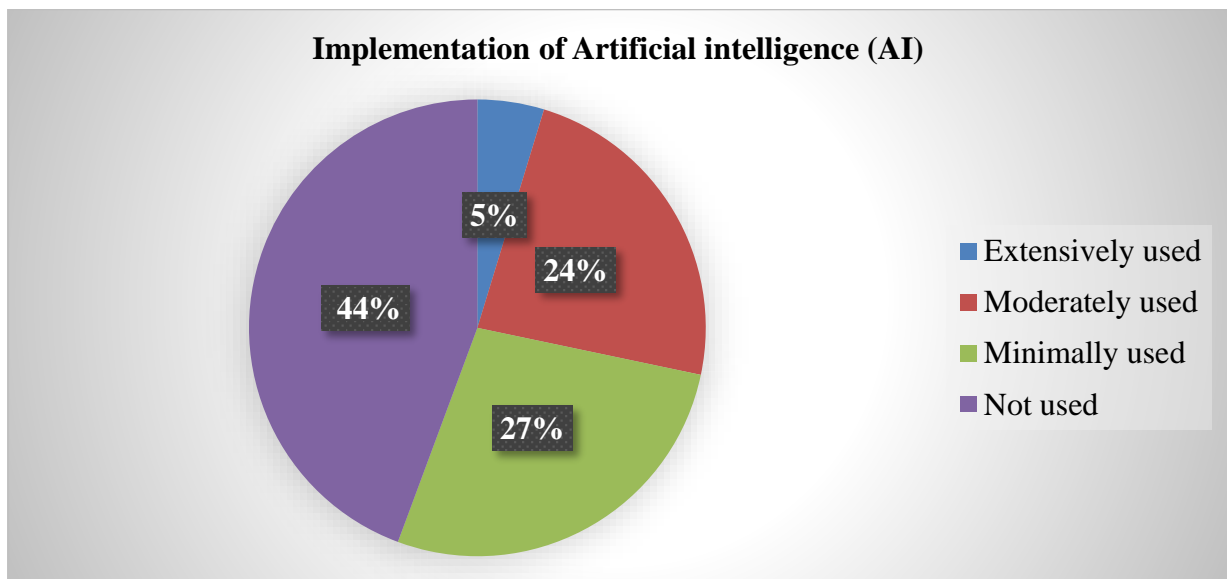


Figure 6: Implementation of Artificial Intelligence (AI)

As seen in Figure 6 above, the respondents were asked to what extent libraries had implemented artificial intelligence (AI) for cataloguing and indexing. The study found that 15 respondents (14%) indicated they had not considered AI, 29 (27%) reported they were planning to implement it, 39 (37%) said they were partially implementing it, and 23 (22%) stated they had

fully implemented AI. This distribution showed that while full adoption was not yet widespread, there was clear momentum toward increasing AI integration in library systems.

4.4.4 Machine Learning Algorithms for Personalised Recommendation Services

Table 13: Machine Learning Algorithms

		Frequency	Percent
Valid	Frequently	10	9.4
	Occasionally	31	29.2
	Rarely	30	28.3
	Never	35	33.0
	Total	106	100.0%

In Table 13 above, respondents were asked how often their libraries used machine learning algorithms for personalized recommendation services. The study found that 10 respondents (9.4%) indicated they used it frequently, 31 (29.2%) reported using it occasionally, 30 (28.3%) reported using it rarely, and the majority 35 (33%) reported never using it. This distribution suggested that while there was interest and some implementation of personalized recommendations through machine learning, many libraries still relied on traditional methods or had yet to explore these modern technological solutions.

4.4.5 Current Status of Robotic Automation for Routine Tasks

As seen in Table 14 below, respondents were asked about the status of robotic automation for routine tasks such as book sorting and shelving in their libraries. The study revealed that 11 respondents (10.4%) indicated that robotic automation was fully operational, 12 (11.3%) had been in the pilot phase, 35 (33%) had been in the planning stage, and the majority 48 (45.3%) had not considered robotic automation for routine tasks. Overall, these findings illustrated a transitional phase within library operations regarding automation, with many institutions weighing their options and assessing the feasibility and benefits of integrating robotics into their workflows.

Table 14: Current Status of Robotic Automation for Routine Tasks

		Frequency	Percent
Valid	Fully operational	11	10.4
	Pilot phase	12	11.3
	Planning stage	35	33.0
	Not considered	48	45.3
	Total	106	100.0%

4.4.6 Virtual Reality (VR) and Augmented Reality (AR) Technologies

As depicted in Figure 7 below, respondents were asked to what extent virtual reality (VR) and augmented reality (AR) technologies were used in libraries for educational purposes. The study found that 5 respondents (5%) reported extensive use of these technologies, 25 (24%) reported moderate use, 29 (27%) reported minimal use, and the majority 47 (44%) reported that these technologies had not been used at all. These results indicate that, despite the growing potential of VR and AR technologies in education, their integration into library settings remains limited.

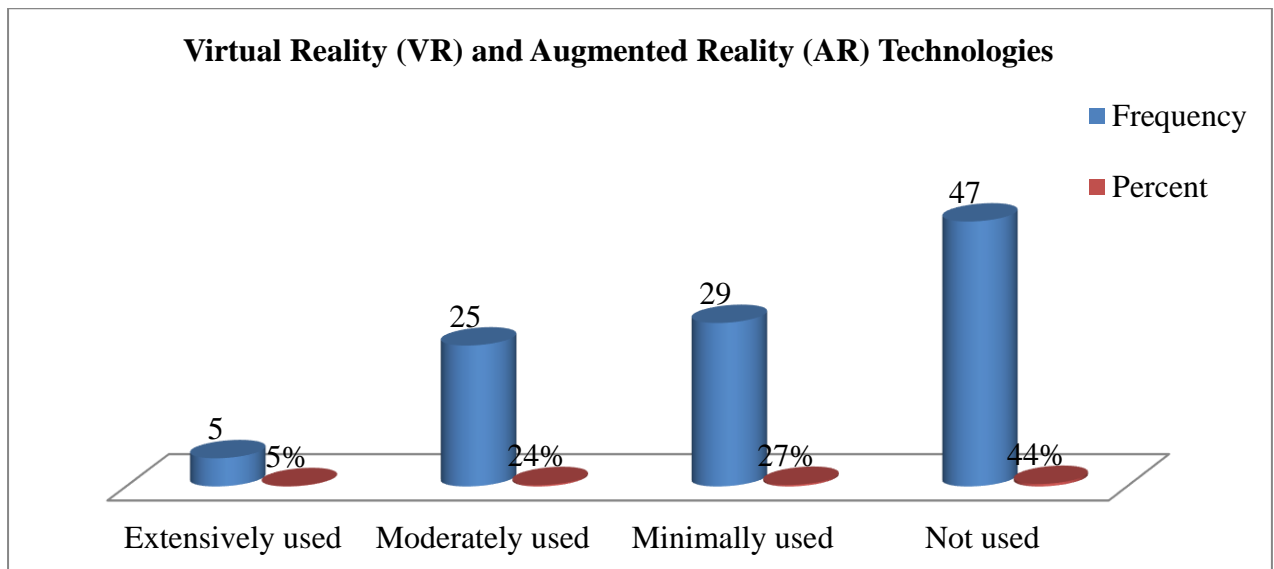


Figure 7: Virtual Reality (VR) and Augmented Reality (AR) Technologies

4.4.7 Internet of Things

As seen in Table 15 below, respondents were asked if they had integrated Internet of Things (IoT) devices, such as smart sensors and radio frequency identification (RFID), for managing library resources. The study found that 13 respondents (12.3%) had fully integrated these technologies, 19 (17.9%) had partially integrated them, 31 (29.2%) were in the planning stage, and majority 43 (40.6%) had not integrated them at all. These results suggested that, while there was some movement towards integrating Internet of Things (IoT) technologies in library resource management, many libraries remained hesitant or unprepared to implement these innovations.

Table 15: Internet of Things

		Frequency	Percent
Valid	Fully integrated	13	12.3
	Partially integrated	19	17.9
	In planning stage	31	29.2
	Not integrated	43	40.6
	Total	106	100.0%

4.4.8 Blockchain Technology in Digital Rights Management

As shown in Table 16 below, respondents were asked about the level of blockchain technology adoption in digital rights management within their libraries. The study revealed that 8 respondents (7.5%) indicated it had been fully adopted, 13 (12.3%) said it had been partially adopted, 33 (31.1%) stated they had been exploring its possibilities, and the majority 52 (49.1%) reported they had not adopted blockchain technology for digital rights management. These results suggested that while there was interest in blockchain for digital rights management, widespread implementation had yet to occur across academic libraries.

Table 16: Blockchain Technology

		Frequency	Percent
Valid	Fully adopted	8	7.5
	Partially adopted	13	12.3
	Exploring possibilities	33	31.1
	Not adopted	52	49.1
	Total	106	100.0%

4.4.9 Data Analytics

As indicated in Figure 8 below, respondents were asked how frequently their libraries used data analytics and big data to enhance decision-making processes. The study found that 5 respondents (4.7%) indicated that they used these tools very frequently, 13 (12.3%) indicated occasionally, 21 (19.8%) indicated rarely, and the majority 67 (63.2%) indicated never. These findings suggested that data analytics and big data were underutilised in decision-making processes among the surveyed libraries.

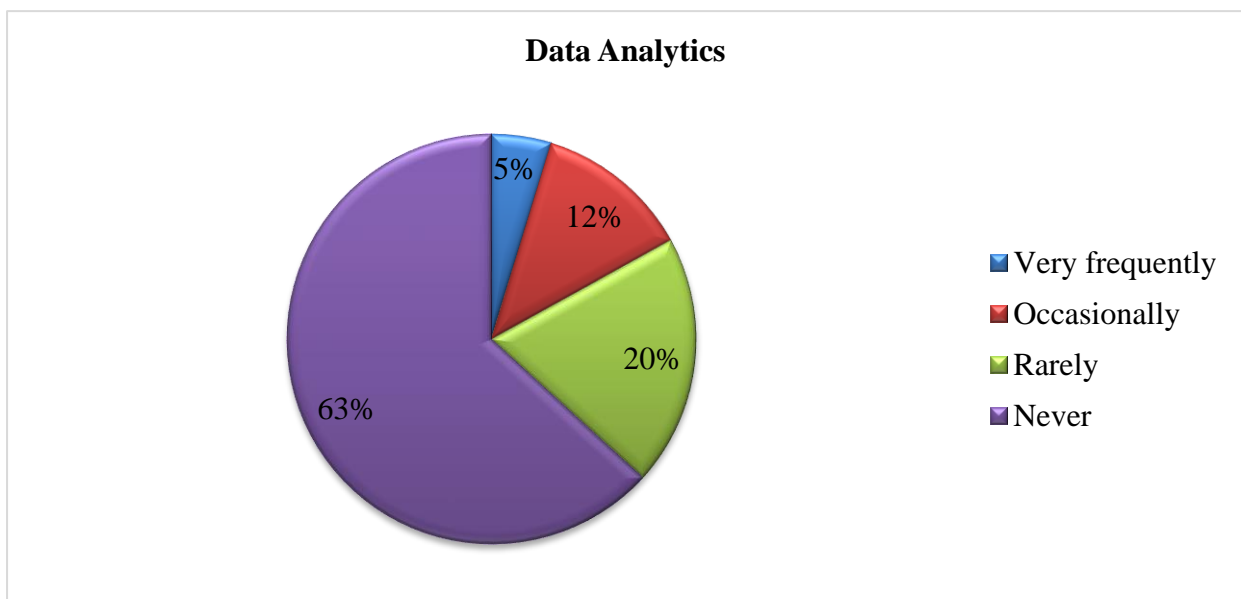


Figure: 8 Data Analytics

4.4.10 Cloud Computing Services Used for Storing and Accessing Library Data

As shown in Table 17 below, respondents were asked to what extent cloud computing services were used for storing and accessing library data. The study revealed that 11 respondents (10.4%) indicated that cloud services were extensively used, 21 (19.8%) reported moderate use, 34 (32.1%) stated minimal use, and the majority of respondents, 40 (37.7%), said these services were not used at all. This indicated that a substantial portion of libraries had yet to integrate cloud computing into their operations.

Table 17: Cloud Computing Services

		Frequency	Percent
Valid	Extensively used	11	10.4
	Moderately used	21	19.8
	Minimally used	34	32.1
	Not used	40	37.7
	Total	106	100.0%

4.4.11 Adoption of Chatbots in Providing User Support and Reference Services

From Table 18 below, respondents were asked about the effectiveness of adopting chatbots for providing user support and reference services. The study found that 32 respondents (21.7%) rated the adoption as very effective, 17 (16%) had considered it somewhat effective, 14 (13.2%) had found it ineffective, and the majority 52 (49%) indicated that chatbots had not been adopted in their library.

Table 18: Adoption of Chatbots

		Frequency	Percent
Valid	Very effective	23	21.7
	Somewhat effective	17	16
	Ineffective	14	13.2
	Not adopted	52	49
	Total	106	100.0%

4.4.12 Current Stage of Implementing 3D Printing Services in Library

As depicted in Figure 9 below, respondents were asked about the stage of implementing 3D printing services in their libraries for educational and research purposes. The study found that 6 respondents (6%) had fully implemented 3D printing services, the majority 41 (39%) were in the process of partial implementation, 23 (22%) were in the planning stage, and 6 (6%) had not considered implementing these services. Overall, the findings suggested that while there was a notable movement toward incorporating 3D printing in libraries, full adoption was still in progress for most institutions.

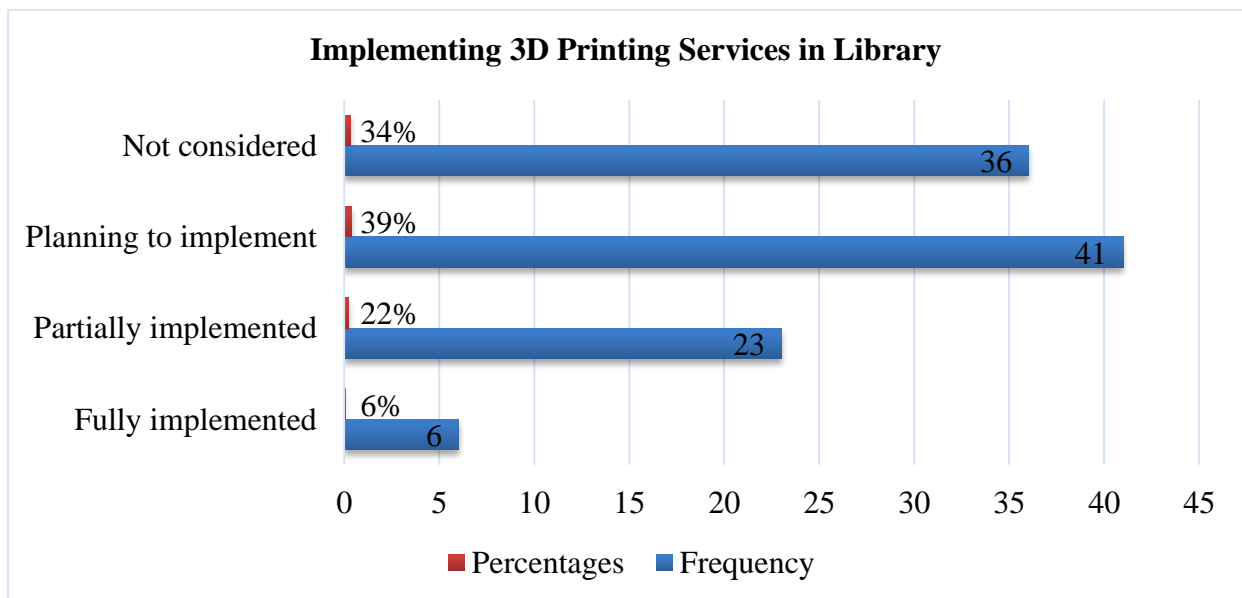


Figure 9: Implementing 3D Printing Services in Library

4.4.13 Reasons for Using Lib 4.0 Technologies and Applications in a Library

In Table 19 below, respondents were asked about the reasons for using Lib 4.0 technologies and applications in their libraries. The majority 31 respondents (29.2%) said they used these technologies to make library services easier to use and more accessible; 16 (15.1%) stated that they aimed to inspire and inform patrons to utilize library services; 22 (22.7%) indicated that the technologies helped patrons learn new skills; 27 (25.5%) mentioned that staying relevant in providing library services was a key reason; and 10 (9.4%) cited attracting new customers and maintaining existing ones as important factors. Overall, these findings illustrated that libraries leveraged Lib 4.0 technologies not only to enhance service delivery but also to foster community engagement and ensure their ongoing relevance in a digital age.

Table 19: Reasons for Using Lib 4.0 Technologies and Applications in a Library

		Frequency	Percent
Valid	To make library services easier to use and accessible	31	29.2
	To inspire and inform patrons to patronize library services	16	15.1
	To help patrons learn new skills	22	20.7
	To stay relevant in providing library services	27	25.5
	To attract new and maintain existing customers	10	9.4
	Total	106	100.0%

4.5 Fourth Industrial Revolution Influencing Information Access and Retrieval Methods in Academic Libraries

The Fourth Industrial Revolution (4IR) is significantly transforming information access and retrieval methods in academic libraries. With the integration of emerging technologies such as artificial intelligence (AI), big data, cloud computing, and the Internet of Things (IoT), libraries are evolving from traditional book-centric models to dynamic, digitally-driven hubs.

4.5.1 Technological Advancement that is most Commonly Used in Academic Libraries for Information Retrieval

The results from Figure 10 below, indicated a clear preference for modern technological advancements in academic libraries, particularly highlighting the effect of the Fourth Industrial Revolution on information retrieval methods. The results revealed that 15 respondents (14%) indicated printed catalogues, the majority 59 (56%) selected barcode scanning, 27 (25%) identified artificial intelligence (AI), and 5 (5%) chose fax machines. These results suggested that barcode scanning, a relatively established technology, is widely relied upon, likely due to its effectiveness and ease of integration into existing library systems.

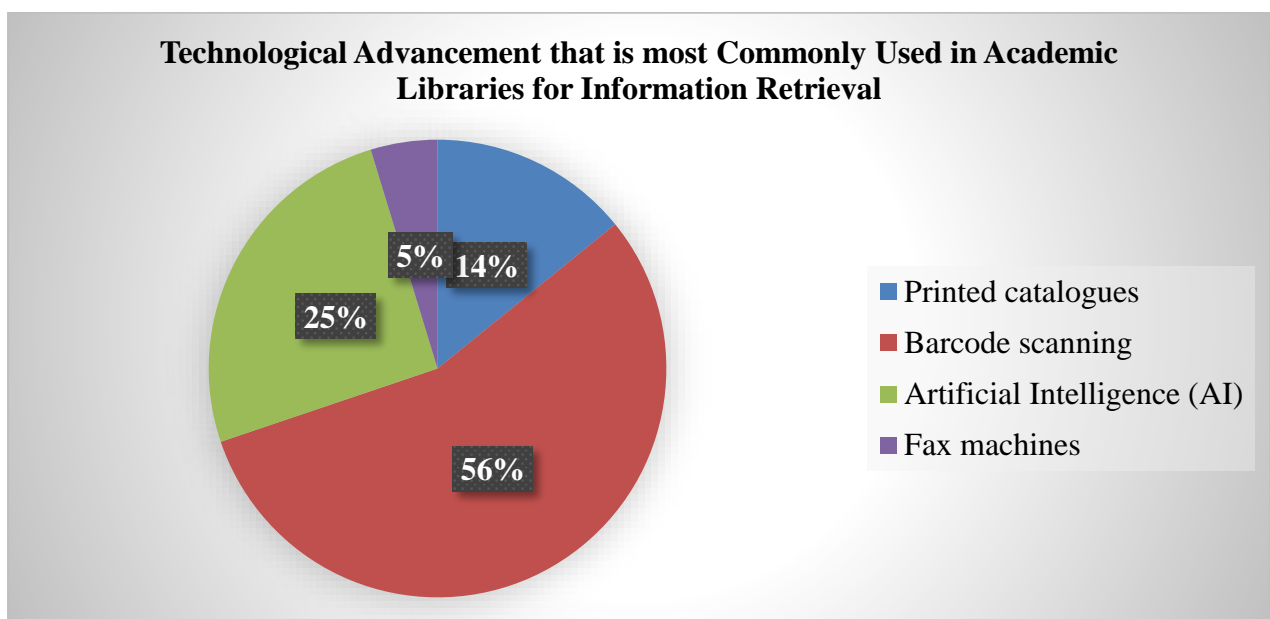


Figure 10: Technological Advancement that is most Commonly Used in Academic Libraries for Information Retrieval

4.5.2 Fourth Industrial Revolution impacting the roles of librarians in academic libraries

As depicted in Table 20 below, the findings from the study indicated a significant shift in the roles of librarians within academic libraries due to the Fourth Industrial Revolution. The study found that 6 respondents (5.7%) reported an increase in manual cataloguing tasks, 18 (17%) noted a reduced need for librarians, and a significant majority of 78 (73.6%) indicated enhanced roles in managing digital resources. In contrast, 4 (3.8%) stated that there was no significant impact. Overall, these findings highlighted a trend toward digital skill enhancement and adaptation in librarianship, with a nuanced balance between technology-driven efficiency and the changing demands of academic resource management.

Table 20: Fourth Industrial Revolution Impacting the Role of Librarians in Academic Libraries

		Frequency	Percent
Valid	Increased manual cataloguing tasks	6	5.7
	Reduced the need for librarians	18	17
	Enhanced roles in managing digital resources	78	73.6
	No significant impact	4	3.8
	Total	106	100.0%

4.5.3 Primary Benefit of AI in Academic Library Information Retrieval

As indicated in Table 21 below, respondents were asked about the primary benefit of AI in academic library information retrieval. The findings revealed that 8 respondents (7.5%) indicated faster processing of physical books, the majority 89 (84%) cited improved accuracy in search results, 6 (5.7%) mentioned lower costs of physical infrastructure, and 3 (3.8%) highlighted increased physical book circulation. These results implied that while there were multiple potential advantages to integrating AI into library systems, the enhancement of search accuracy stood out as the most significant factor influencing user perception and satisfaction.

Table 21: Primary Benefit of AI in Academic Library Information Retrieval

		Frequency	Percent
Valid	Faster processing of physical books	8	7.5
	Improved accuracy in search results	89	84
	Lower costs of physical infrastructure	6	5.7
	Increased physical book circulation	3	2.8
	Total	106	100.0%

4.5.4 Effect of the Fourth Industrial Revolution on User Access to Academic Library Resources

As shown in Table 22 below, respondents were asked about the effect of the Fourth Industrial Revolution on user access to academic library resources. The study found that 2 respondents (1.9%) reported decreased online access, 10 (9.4%) noted an increase in physical library visits, the majority 91 (85.8%) indicated enhanced remote access to digital collections, and 3 (2.8%) mentioned a reduction in the availability of e-books. These results suggested that advancements in technology had facilitated greater accessibility to online resources, aligning with the goals of modern academic libraries to provide comprehensive digital services.

Table 22: Effect of the Fourth Industrial Revolution on User Access to Academic Library Resources

		Frequency	Percent
Valid	Decreased online access	2	1.9
	Increased physical visits to libraries	10	9.4
	Enhanced remote access to digital collections	91	85.8
	Reduced availability of e-books	3	2.8
	Total	106	100.0%

4.5.5 Types of Information Retrieval Method

As depicted in Table 23 below, the respondents were asked about the information retrieval methods that have become more prevalent in academic libraries due to advancements in the Fourth Industrial Revolution. The study indicated that 5 respondents (4.7%) mentioned manual card catalogues, a substantial majority of 86 (81.1%) pointed to online databases with advanced search algorithms, 4 (3.8%) cited paper-based indexing, and 11 (10.4%) referred to book-by-book physical searches. These results showed that online resources underscores the importance of technological integration in academic libraries to meet the evolving needs of users in an era characterized by rapid technological advancement.

Table 23: Types of Information Retrieval Method

		Frequency	Percent
Valid	Manual card catalogues	5	4.7
	Online databases with advanced search algorithms	86	81.1
	Paper-based indexing	4	3.8
	Book-by-book physical searches	11	10.4
	Total	106	100.0%

4.5.6 Academic Libraries Enhancing User Experience with the help of Fourth Industrial Revolution Technologies

As seen in Table 24 below, the respondents were asked how academic libraries had enhanced user experience with the help of Fourth Industrial Revolution technologies, and the study found that 11 respondents (10.4%) indicated maintenance of more printed journals. The majority, 70 (66%), cited the introduction of automated chatbots for assistance, 6 (5.7%) mentioned limiting access to digital resources, and 19 (17.9%) indicated a reduction in the number of library staff. Overall, these findings illustrated a transformative shift in academic libraries towards technology-driven solutions that prioritized user convenience and efficiency.

Table 24: Academic Libraries Enhancing User Experience with the Help of Fourth Industrial Revolution Technologies

		Frequency	Percent
Valid	By maintaining more printed journals	11	10.4
	By introducing automated chatbots for assistance	70	66
	By limiting access to digital resources	6	5.7
	By reducing the number of library staff	19	17.9
	Total	106	100.0%

4.6.7 Direct Result of the Fourth Industrial Revolution in Academic Library Resource Management

As shown in Table 25 below, the findings from the study indicated a significant shift in academic library resource management as a direct result of the Fourth Industrial Revolution, with a clear emphasis on digital transformation. The overwhelming majority of respondents, 76 (71.6%), identified the development of digital repositories as the primary outcome, highlighting a trend towards digitisation and improved accessibility of resources. Additionally, 15 (14.2%) mentioned an increased use of typewriters for documentation, 9 (8.5%) pointed to greater reliance on microfilm archives, and 6 (5.6%) noted a heightened emphasis on physical book preservation. This disparity underscored a transformative period for libraries, where digital solutions were prioritised over conventional documentation methods, indicating a progressive adaptation to technological advancements.

Table 25: Direct Result of the Fourth Industrial Revolution in Academic Library Resource Management

		Frequency	Percent
Valid	More reliance on microfilm archives	9	8.5
	Development of digital repositories	76	71.7
	Increased use of typewriters for documentation	15	14.2
	Greater emphasis on physical book preservation	6	5.6
	Total	106	100.0%

4.6 Assessing the Skills and Training Requirements of Library Staff in Response to the Fourth Industrial Revolution

Library professionals must acquire new skills in digital literacy, data management, information technology, and AI-driven tools to efficiently manage and curate resources in an increasingly digital environment. Training programs need to focus on enhancing staff competencies in emerging technologies such as cloud computing, virtual reality, and automated systems, ensuring that libraries remain relevant and continue to provide valuable services.

4.6.1 Confident in Using Digital Library Management Systems

As demonstrated in Figure 11 below, the study revealed a generally positive outlook among respondents regarding their confidence in using digital library management systems. A total of 46 respondents (43%) expressed confidence, and 44 (42%) indicated they were very confident. Meanwhile, 13 (12%) were somewhat confident, and a small percentage, 3 (3%), were not confident. This distribution indicated that while most users were comfortable with digital library management systems, a minority could have benefited from additional training or support to enhance their proficiency.

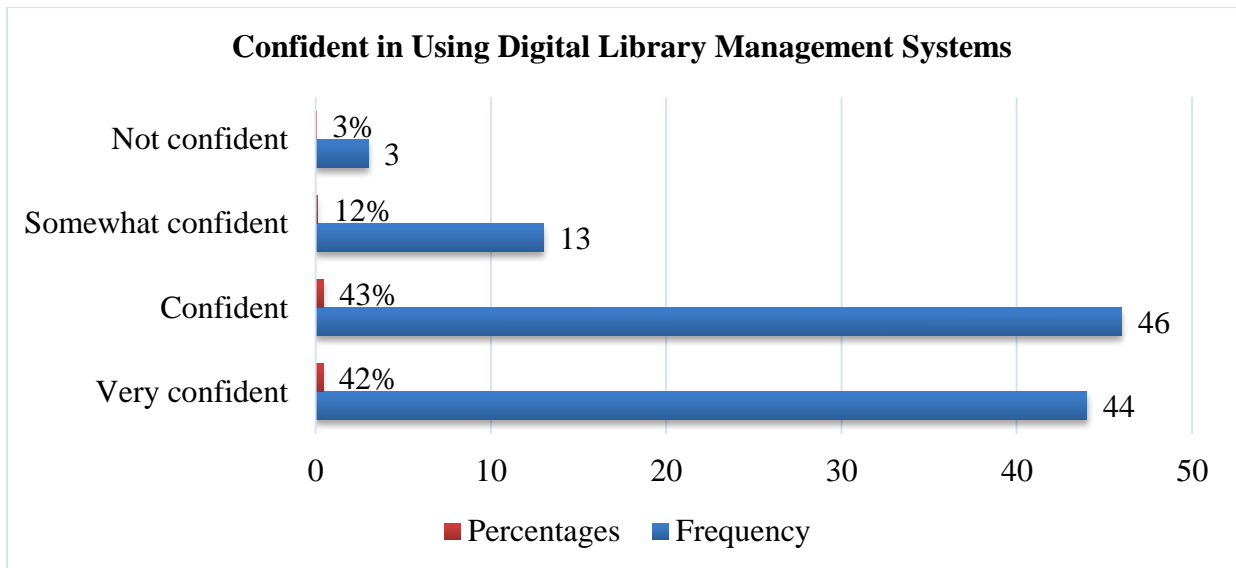


Figure 11: Confident in Using Digital Library Management Systems

4.6.2 Engaged in professional development activities related to emerging technologies

Figure 12 below, shows how often academic librarians engaged in professional development activities related to emerging technologies. The majority, 54 (51%), reported that they engaged frequently, 29 (27%) indicated occasionally, 17 (16%) rarely, and 6 (6%) stated that they never engaged in such activities. Overall, this trend demonstrated a strong commitment among academic librarians to maintain technological competencies, although some barriers to regular participation may have existed.

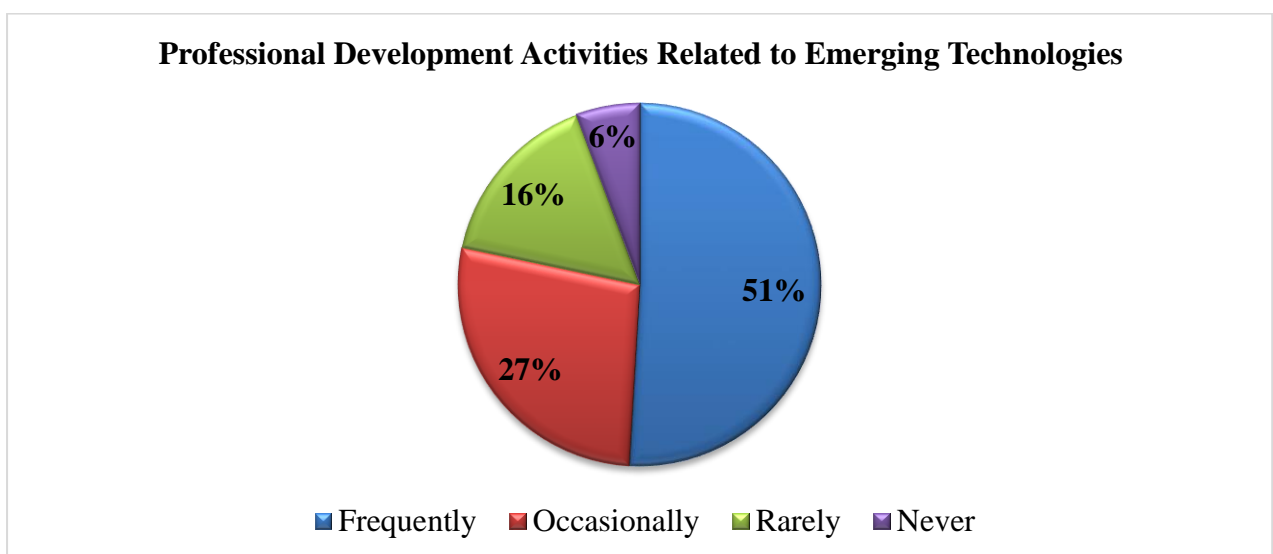


Figure 12: Professional Development Activities Related to Emerging Technologies

4.6.3 Familiar with Data Analytics Tools for Library Management

In Table 26 below, the respondents were asked about their familiarity with data analytics tools for library management. The study revealed that 31 respondents (29.2%) had reported being very familiar, 44 (41.5%) were familiar, 19 (17.9%) were somewhat familiar, and 12 (11.3%) were not familiar. This suggested that a significant portion of the respondents had a solid understanding of these tools, which could have been beneficial for library management practices. However, there was still a notable proportion who were either somewhat familiar or not familiar.

Table 26: Familiar with Data Analytics Tools for Library Management

		Frequency	Percent
Valid	Very familiar	31	29.2
	Familiar	44	41.5
	Somewhat familiar	19	17.9
	Not familiar	12	11.3
	Total	106	100.0%

4.6.4 Rating the Ability to Teach Patrons How to Use New Digital Resources

According to the results presented in Figure 13 below, respondents were asked to rate their ability to teach patrons how to use new digital resources. The study revealed that the majority, 54 respondents (51%), rated their ability as good, while 32 (30%) rated it as excellent. Fourteen (13%) rated their ability as fair, and three (3%) rated it as poor. This suggested that most respondents possessed satisfactory proficiency in guiding patrons through digital tools, which was crucial in the increasingly technology-driven environment.

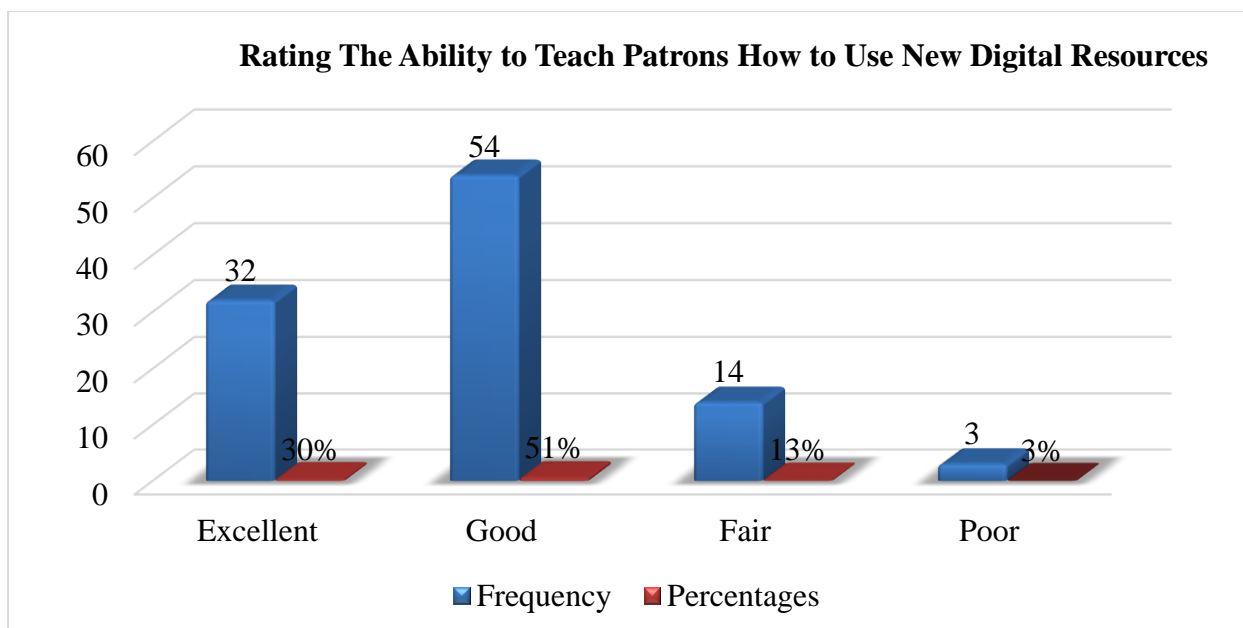


Figure 13: Rating the Ability to Teach Patrons How To Use New Digital Resources

4.6.5 Level of Comfort When Using Artificial Intelligence (AI)-Based Library Systems

From the results as presented in Table 27, respondents were asked about their level of comfort with using artificial intelligence (AI)-based library systems. The study found that 29 respondents (27.4%) reported very comfortable, the majority, 55 (51.9%), said comfortable, 18 (17%) indicated somewhat comfortable, and 4 (3.8%) were not comfortable. Overall, the results suggested a promising acceptance of artificial intelligence in library settings but highlighted an opportunity to address minor concerns among less comfortable users.

Table 27: Level of Comfort when Using AI-Based Library Systems

		Frequency	Percent
Valid	Very comfortable	29	27.4
	Comfortable	55	51.9
	Somewhat comfortable	18	17
	Not comfortable	4	3.8
	Total	106	100.0%

4.6.6 Understanding the Concept of Digital Literacy and its Importance

As demonstrated in Table 28 below, respondents were asked how well they understood the concept of digital literacy and its importance. The results showed that the majority, 52 respondents (49.1%), reported understanding it well; 37 (34.9%) said they understood it very well; 11 (10.4%) indicated somewhat; and 6 (5.7%) said they did not understand it at all. These results highlighted that, while awareness of digital literacy was relatively high, there was still a need for targeted education to ensure that everyone has a comprehensive understanding of its significance.

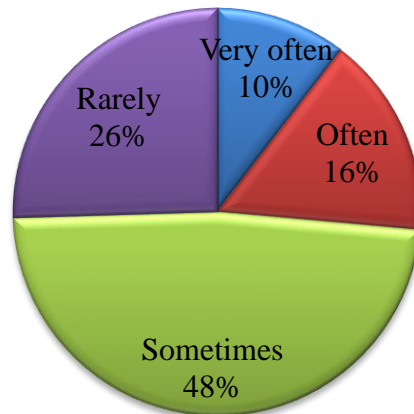
Table 28: Understanding the Concept of Digital Literacy and its Importance

		Frequency	Percent
Valid	Very well	37	34.9
	Well	52	49.1
	Somewhat	11	10.4
	Not at all	6	5.7
	Total	106	100.0%

4.6.7 Participating in Training Programs Related to Fourth Industrial Revolution Technologies

The survey results in Figure 14 below, indicated a varied perception among respondents regarding the frequency of participation in training programs related to Fourth Industrial Revolution technologies. The study found that 11 (10%) said very often, 17 (16%) said often, the majority, 51 (48%), indicated sometimes, and 27 (26%) said rarely. This distribution indicated that while there had been some engagement with training related to emerging technologies, a substantial number of individuals had been either infrequently or only occasionally involved.

Participating in Training Programs Related to Fourth Industrial Revolution Technologies



■ Very often ■ Often ■ Sometimes ■ Rarely

Figure 14: Participating in training programs

4.6.8 Proficient in Using Cloud-Based Library Services and Integrating Virtual Reality (VR) or Augmented Reality (AR) Into Library Services

As seen in Table 29 below, the respondents were asked about their proficiency in using cloud-based library services and integrating virtual reality (VR) or augmented reality (AR) into library services. The study revealed that 12 respondents (11.3%) indicated very proficient, 28 (26.4%) were proficient, the majority, 43 (40.6%), had been somewhat proficient, and 23 (21.7%) were not proficient. The findings suggested that while a notable portion of respondents were proficient in using cloud-based library services and integrating VR/AR technologies, the majority still possessed only a moderate level of proficiency.

Table 29: Proficient in Cloud-Based Library Services and Integrating Virtual Reality or Augmented Reality into Library Services

		Frequency	Percent
Valid	Very proficient	12	11.3
	Proficient	28	26.4
	Somewhat proficient	43	40.6
	Not proficient	23	21.7
	Total	106	100.0%

4.6.9 Important of Ongoing Training in Emerging Technologies for Library Staff

In Figure 15 below, respondents were asked about the importance of ongoing training in emerging technologies for library staff. The study found that 39 respondents (37%) said it was extremely important, while the majority, 55 respondents (52%), indicated it was very important. Additionally, 10 (9%) felt it was somewhat important, and 2 (2%) said it was not important at all. Overall, the results underscored a clear priority among respondents for training to keep library staff adept with emerging technologies.

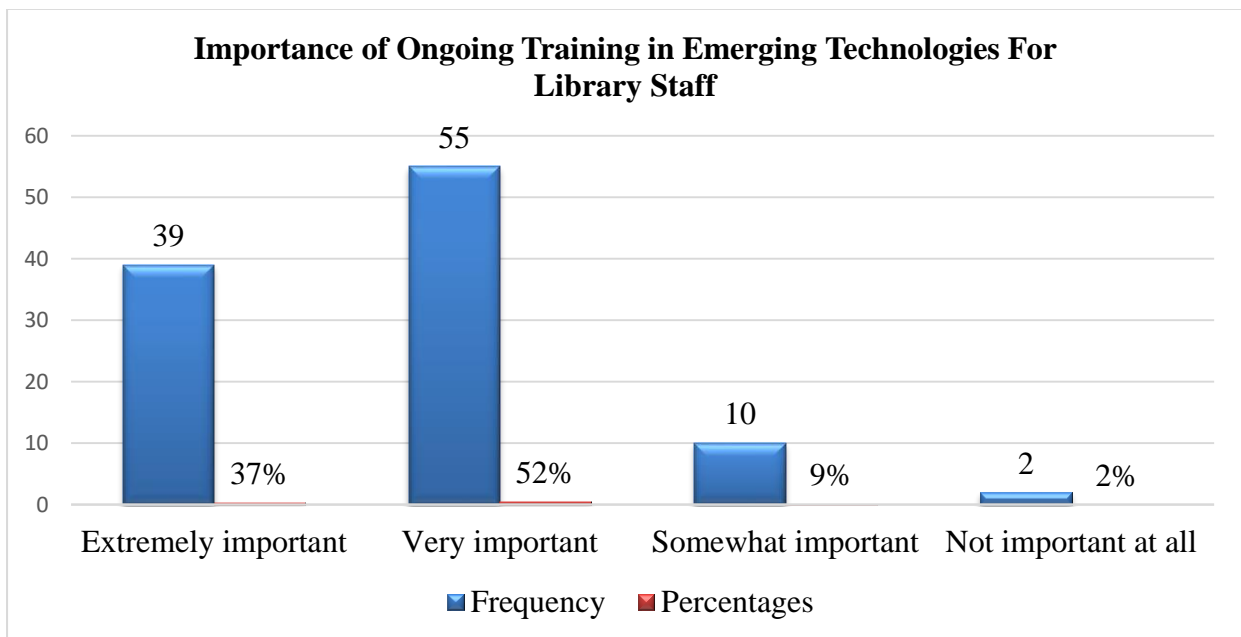


Figure 15: Importance of Ongoing Training in Emerging Technologies for Library Staff

4.6.10 Types of Training Most Beneficial for Library Staff in a Technologically Evolving Environment

According to Table 30, respondents were asked about the type of training they considered most beneficial for library staff in a technologically evolving environment. The majority, 43 respondents (40.6%), indicated that digital literacy and technology proficiency were the most beneficial. This was followed by 29 (27.4%) who preferred training in artificial intelligence and machine learning, 21 (19.8%) who chose data management and analytics, and 19 (12.3%) who selected digital content curation and preservation. Overall, these findings suggested that library staff prioritized training that not only kept pace with technological evolution but also positioned them to leverage these tools for improved service delivery.

Table 30: Types of Training Most Beneficial for Library Staff in a Technologically Evolving Environment

		Frequency	Percent
Valid	Digital literacy and technology proficiency	43	40.6
	Artificial intelligence and machine learning	29	27.4
	Data management and analytics	21	19.8
	Digital content curation and preservation	13	12.3
	Total	106	100.0%

4.6.11 Rating the Current Skills Levels of Staff in Handling Fourth Industrial Revolution Technologies

In Table 31 below, respondents were asked to rate the current skill level of staff in handling Fourth Industrial Revolution technologies. The study revealed that 20 respondents (18.9%) rated them as highly skilled, 57 (53.8%) rated them as moderately skilled, 25 (23.6%) rated them as slightly skilled, and 4 (3.8%) rated them as not skilled at all. This distribution reflected an overall confidence in the staff's ability to engage with emerging technologies.

Table 31: Rating the Current Skills Levels of Staff in Handling Fourth Industrial Revolution Technologies

		Frequency	Percent
Valid	Highly skilled	20	18.9
	Moderately skilled	57	53.8
	Slightly skilled	25	23.6
	Not skilled at all	4	3.8
	Total	106	100.0%

4.6.12 Descriptive Statistics on the Constructs of Fourth Industrial Revolution (4IR) Technologies

In Table 32 below, respondents were asked to rate the perceived usefulness, perceived ease of use, attitude towards using, and behavioural intention to use Fourth Industrial Revolution (4IR) technologies. The findings indicate that librarians generally perceive emerging technologies positively, with AI being highly regarded for its ability to enhance performance and ease of use. The mean score of 3.79 for AI suggests strong agreement regarding its usefulness, while the lower standard deviation of 1.22 indicates a consistent experience among users. In comparison, IoT received a lower mean of 3.47, indicating moderate recognition of its benefits but with greater variability in responses (SD 1.37). Similarly, Big Data tools showed a mixed reception, with a mean of 3.52 and a higher SD of 1.34, suggesting that while they were perceived as beneficial, users found them more challenging compared to AI-driven systems.

Librarians expressed a generally positive attitude toward adopting advanced technologies such as AR, VR, cloud computing, and automation. The mean score of 3.60 for AR and VR suggests moderate intent to use these technologies, though the high variability (SD 1.47) reflects differing opinions. Cloud computing received a more consistent and favorable outlook, with a mean of 3.75 and a lower SD of 1.23. The intention to use automation in libraries was also strong, with a mean of 3.84, indicating enthusiasm for this technology. However, blockchain received the lowest mean score (3.24) and the highest SD (1.45), highlighting uncertainty or limited understanding about its potential applications in library settings. Overall, librarians

were enthusiastic about familiar and accessible technologies, though more specialized innovations like blockchain were met with caution.

Table 32: Descriptive Analysis on the Constructs

Statements	Mean	Standard Deviation
Perceived Usefulness (PU)		
Using AI in the library improves my performance.	3.79	1.22
Using IoT increases my productivity.	3.47	1.37
Perceived Ease-of-Use (PEOU)		
AI-driven cataloguing systems are easy to use.	4.15	0.94
Interaction with Big Data is clear and understandable.	3.52	1.34
Attitude towards Using		
I intend to use AR and VR if accessible.	3.60	1.47
I have a positive attitude towards cloud computing.	3.75	1.23
Behavioural Intention to Use		
I will recommend automation in libraries.	3.84	1.36
I intend to use blockchain in future library jobs.	3.24	1.45

4.6.13 Integrating Fourth Industrial Revolution Technologies in Library Service

As seen in Table 34 below, respondents were asked to indicate the extent to which they strongly agreed (SA), agreed (A), disagreed (D), or strongly disagreed (SD) with five statements regarding the integration of Fourth Industrial Revolution technologies in library services. The findings in Table 34 revealed a generally positive perception of emerging technologies in academic libraries, with a majority of respondents agreeing or strongly agreeing with their benefits. Artificial intelligence (AI) was seen as significantly enhancing the user experience,

as 91.4% (48.1% + 43.3%) of respondents either strongly agreed or agreed. Similarly, the Internet of Things (IoT) was widely recognized for improving resource management efficiency, with 93.3% (43.3% + 50%) expressing agreement.

Big data analytics also received strong support for aiding data-driven decision-making, with 87.7% (39.6% + 48.1%) of respondents agreeing or strongly agreeing. Automation stood out as the most favourably viewed technology, with 92.4% (52.8% + 39.6%) perceiving it as effective in streamlining routine tasks and boosting operational efficiency. However, blockchain technology garnered slightly lower support, with 73.6% (45.3% + 28.3%) agreeing or strongly agreeing about its role in enhancing security and transparency, while 24.5% expressed disagreement. This disparity suggested that while blockchain’s benefits were recognised, concerns about its practical implementation and scalability in library settings might have persisted. The findings also suggested a broad, positive perception of emerging technologies.

Table 33: Integrating Fourth Industrial Revolution Technologies in Library Service

Statements	Strongly agree	Agree	Disagree	Strongly disagree
The adoption of artificial intelligence in academic libraries enhances the user experience.	51 (48.1%)	38 (43.3%)	10 (9.4%)	7 (6.6%)
The implementation of the Internet of Things (IoT) in academic libraries improves resource management efficiency.	46 (43.3%)	53 (50%)	3 (2.8%)	5 (4.7%)
Utilising big data analytics in academic libraries aids in data-driven decision making.	42 (39.6%)	51 (48.1%)	4 (3.8%)	6 (5.7%)
The use of automation in academic libraries automates routine tasks and improves operational efficiency.	56 (52.8%)	42 (39.6%)	5 (4.7%)	3 (2.8%)
The integration of blockchain technology in academic libraries improves security and transparency.	48 (45.3%)	30 (28.3%)	17 (16%)	9 (8.5%)

4.6.14 Hypothesis Testing Using Chi-square Test of Independence

The researcher proceeded to test whether there was an association between the five independent variables namely, Perceived Usefulness (PU), Perceived Ease-of-Use (PEOU), Attitude towards Using and Behavioural Intention to Use. Before conducting the test, a plan of analysis

was formulated, using 0.05 as the significance level (P-value). According to this plan, if the test statistic's probability was less than the formulated significance level (0.05), the null hypothesis was rejected. However, if the P-value was greater than 0.05, the null hypothesis was not rejected, and the alternative hypothesis was not accepted. Therefore, four hypotheses were formulated and tested separately as follows:

4.6.14.1 Chi-square Test on Perceived Usefulness and Adoption of 4IR Technologies in Libraries

H₀: There is no significant relationship between the perceived usefulness of 4IR technologies and their adoption in academic libraries."

H₁: There is a significant relationship between the perceived usefulness of 4IR technologies and their adoption in academic libraries.

Table 34: Chi-square Test on Perceived Usefulness

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.376 ^a	9	.000
Likelihood Ratio	11.145	9	.000
Linear-by-Linear Association	5.692	1	.000
N of Valid Cases	106		

a. 6 cells (37.5%) have expected count less than 5. The minimum expected count is 1.13.

The results in Table 34 showed that $\chi^2 = 11.376$, $DF = 9$, and the p-value = 0.000. Since the p-value (0.000) was less than the significance level of 0.05, the null hypothesis was rejected, and the alternative hypothesis was accepted. There is a significant relationship between the perceived usefulness of 4IR technologies and their adoption in academic libraries.

4.6.14.2 Chi-Square Tests on Perceived Ease-of-Use (PEOU) and Adoption of 4IR Technologies in Libraries

H₀ There is no significant relationship between the adoption of 4IR technologies and the ease of use in academic libraries.

H₁: There is a significant relationship between the adoption of 4IR technologies and the ease of use in academic libraries.

Table 35: Chi-Square Tests on Perceived Ease-of-Use (PEOU)

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.772 ^a	2	.000
Likelihood Ratio	17.162	2	.000
Linear-by-Linear Association	3.419	1	.000
N of Valid Cases	106		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is .06.

The results in Table 35 above showed that the p-value of 25.772^a was associated with a significance value of 0.000. Therefore, since the significance value (0.000) was less than 0.05, we rejected the null hypothesis in favour of the alternative hypothesis. The interpretation is that, there was significant relationship between the adoption of 4IR technology and the ease of use in academic libraries.

4.6.14.3 Chi-Square Tests on Attitude towards Using and Adoption of 4IR Technologies in Libraries

Table 36: Chi-Square Tests on Attitude towards Using

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.088 ^a	9	.000
Likelihood Ratio	9.552	9	.000
Linear-by-Linear Association	.535	1	.005
N of Valid Cases	106		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is .28.4

H₀: There is no significant relationship between the adoption of 4IR technologies and attitude towards Using

H₁: There is a significant relationship between the adoption of 4IR technologies and attitude towards using

The Chi-Square test results in Table 36 assessed the relationship between big data analytics and decision-making. The Pearson Chi-Square statistic (8.088, $p = 0.000$) and the Likelihood Ratio statistic (9.552, $p = 0.000$) indicated a statistically significant association between the variables, as the p -values were less than the 0.05 threshold. Therefore, since the significance value (0.000) was less than 0.05, we rejected the null hypothesis in favour of the alternative hypothesis. The interpretation is that there was a significant relationship between the adoption of 4IR technology and attitude towards using

4.6.14.4 Chi-Square Tests on Behavioural Intention to Use and Adoption of 4IR Technologies in Libraries

H₀: There is no significant relationship between the adoption of 4IR technologies and behavioural intention to use

H₁: There is a significant relationship between the adoption of 4IR technologies and behavioural intention to use

Table 37: Chi-Square Tests on Behavioural Intention to Use

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	31.279 ^a	12	.000
Likelihood Ratio	17.254	12	.140
Linear-by-Linear Association	5.441	1	.020
N of Valid Cases	106		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is .14.

As seen in Table 37 above, the results of the Chi-Square Tests on behavioural intention to use indicated a statistically significant relationship between the two variables. The Pearson Chi-

Square value of 31.279 with 12 degrees of freedom and the significance value of 0.000 suggested that the null hypothesis had been rejected at the 0.05 significance level. The interpretation was that there was a significant relationship between the adoption of 4IR technology and behavioural intention to use

4.7 Challenges Faced By Academic Libraries in Adopting the Fourth Industrial Revolution Technologies in Their Library Services

The study found that the majority, 47 respondents (44.3%), indicated a lack of funding. 22 (20.8%) cited insufficient training for staff, while 6 (5.7%) mentioned resistance to change among staff. 15 (14.2%) reported inadequate technical infrastructure, and 4 (3.8%) expressed fear of losing their jobs as new technology emerged, and 12 (11.3%) indicated a lack of ICT skillsets necessary to utilize Library 4.0 technologies. Altogether, these challenges indicated that successful integration required comprehensive support in financial, technical, and human resources to equip libraries for the digital shift.

Table 38: Challenge Libraries Face in Integrating Fourth Industrial Revolution Technologies

		Frequency	Percent
Valid	Lack of funding	47	44.3
	Insufficient training for staff	22	20.8
	Resistance to change among staff	6	5.7
	Inadequate technical infrastructure	15	14.2
	Fear of losing my job as new technology emerges	4	3.8
	Lack of ICT skillset to utilize Library 4.0 technologies	12	11.3
	Total	106	100.0%

4.8 Summary of Chapter Four

This chapter presented the findings of the research on the Effect of the Fourth Industrial Revolution on Library Services. The study's overall results revealed that the adoption of Fourth Industrial Revolution (4IR) technologies in academic libraries was still evolving, with varying

degrees of implementation across different institutions. The study indicated that libraries were becoming increasingly aware of 4IR tools, primarily through internet resources (38.7%), and were integrating several Library 4.0 (LIB4.0) technologies to improve user experience and operational efficiency. Among the most commonly adopted technologies were digital library repositories (28.3%) and artificial intelligence (18.9%). Other innovations, such as blockchain, IoT, and AI-based cataloguing systems, were being explored but were not yet widely implemented. For example, 37% of libraries had partially implemented AI for cataloguing and indexing, while a significant proportion (45.3%) had not considered robotic automation for routine tasks.

The survey also highlighted the varied stages of adoption for specific 4IR technologies. For instance, data analytics, big data, and cloud computing were underutilised in decision-making processes, with 63.2% of respondents reporting no use of these tools at all. While some libraries had embraced newer technologies, like chatbots (21.7% found them very effective and 3D printing 39% were partially implementing, a substantial portion of libraries still faced barriers to adopting such innovations. The primary drivers for adopting LIB4.0 technologies were to enhance service accessibility, stay relevant in a digital age, and inspire patrons to engage with library resources.

The results of the Chi-Square tests conducted on various factors influencing the adoption of 4IR technologies in academic libraries indicate significant relationships between these factors and adoption. In the first analysis, the perceived usefulness of 4IR technologies was found to have a significant impact on their adoption, as evidenced by a Chi-Square value of 11.376 ($p = 0.000$). Similarly, the perceived ease-of-use (PEOU) was also significantly related to adoption, with a Chi-Square statistic of 25.772 ($p = 0.000$), indicating that users' perceptions of ease-of-use influenced their willingness to adopt 4IR technologies. The results from the attitude towards using 4IR technologies further confirmed this, with both the Pearson Chi-Square and Likelihood Ratio statistics (8.088 and 9.552, respectively, $p = 0.000$) showing a strong association between attitude and adoption.

Finally, the integration of Fourth Industrial Revolution (4IR) technologies in academic libraries faced several challenges, primarily revolving around a lack of funding, insufficient staff training, and resistance to change. The majority of respondents highlighted financial constraints (34.9%) as the most significant barrier, followed by the need for more comprehensive training programs (20.8%) to equip staff with the necessary skills. Additional issues included

inadequate technical infrastructure (14.2%) and a limited understanding of the technologies themselves (9.4%). Smaller percentages pointed to fears of job displacement (3.8%) and a lack of essential ICT skill sets (11.3%). These findings emphasised the need for a holistic approach, addressing both technical and human resource challenges to effectively implement 4IR technologies in academic library services. Having presented the study results in this chapter, Chapter Five follows with discussion of research findings.

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.0 Overview

This chapter discussed the research findings presented in chapter four by interpreting them in relation to the literature review on the subject of the effect of the Fourth Industrial Revolution on library services. It began by briefly examining the findings in terms of the characteristics of the respondents and then discussed the findings according to the research objectives and questions.

5.1 Characteristics of the Respondents

The study revealed that 63 (60%) were female and 43 (40%) were male. These findings highlighted that female librarians were more prevalent in this academic setting. Age played a vital role in determining outcomes or influencing findings in the research. Out of 106 academic librarians in Lusaka Province, 7 (6.6%) were aged 20-26 years, 27 (25.5%) were aged 27-29 years, 16 (15.1%) were aged 30-34 years, 16 (15.1%) were aged 35-39 years, and the majority 40 (37.7%) were 40 years and above. These results suggested that a significant portion of the librarian population likely had substantial experience and potentially higher levels of expertise, which could have influenced library services and management practices.

The study discovered that the majority were categorised as librarians 35 (33%), indicating that this role was the most common within the library setting. The next largest group consisted of assistant librarians 22 (20.8%), followed closely by senior library assistants 17 (16%). Chief librarians and deputy librarians represented a smaller fraction of the workforce, with only 11 (10.4%) and 2 (1.9%) respectively, suggesting that higher managerial roles were less prevalent among this group. Additionally, library assistants comprised 19 (17.9%), reflecting a significant support role within the library structure. This distribution highlighted a hierarchical structure where operational roles such as librarians and assistants dominated, while leadership positions were limited.

The study revealed that 6 (5.7%) were certificate holders, 24 (22.6%) were diploma holders, the majority 47 (44.3%) were bachelors' degree holders, 27 (25.5%) were master's degree holders, and 2 (1.9%) had doctoral degrees. This distribution suggested a relatively high level of educational attainment among the respondents, with most having degrees or higher qualifications. The study also established that 38 respondents (36%) reported having 9 years

or more of work experience, 8 (8%) indicated 5–8 years of work experience, 37 (35%) reported 1–4 years' of work experience, and 23 (22%) stated less than 1 year of work experience. This distribution suggested a workforce skewed towards experienced professionals, while still accommodating a notable number of less experienced individuals.

The study discovered that the majority of respondents 26 (24.5%) worked in the department of reference services, 9 (8.5%) in electronic resources, 13 (12.3%) in the IT support unit, 17 (16%) in the cataloguing department, 10 (9.4%) in the acquisition department, 7 (6.6%) in the institutional repository, and 9 (8.5%) in administration. These findings revealed that the department of reference services had the highest representation among respondents, indicating a strong emphasis on direct user assistance and information retrieval. The study also rated the level of technological adoption in libraries and the results showed that 11 respondents (10%) rated it as very high, 38 (36%) rated it as high, the majority 49 (46%) rated it as moderate, and 8 (8%) rated it as low. These findings suggested that most respondents had perceived the level of technological adoption in their libraries as moderate or high.

5.2 Adopting the Fourth Industrial Revolution Technologies in Library Services

The study found that 16 respondents (15.1%) had learned about it during an information literacy training program, 19 (17.9%) through research work, the majority 41 (38.7%) via the internet, 17 (16%) through social media platforms, 4 (3.8%) from the university website, 4 (3.8%) through staff meetings, and 5 (4.7%) at a conference or seminar. The findings indicated that the internet was the primary source of information about the Fourth Industrial Revolution, with respondents having learned about it through online searches, highlighting the internet's role in disseminating emerging knowledge.

Similarly, Shonhe, Jain and Akakandelwa (2023) revealed that librarians need to be aware of Fourth Industrial Revolution technologies, particularly their capabilities, benefits, and risks, in order to effectively apply them for efficient library service delivery. Obim (2022) found that a lack of awareness of Fourth Industrial Revolution technologies was one of the major challenges affecting their utilisation in libraries. Creating awareness of emerging technologies is fundamental to their adoption and application in organizations and institutions, including university libraries.

Research work and academic training programs were also key contributors to knowledge acquisition about technological advances. A study by Corral and Jolly (2019) highlighted the

importance of structured learning environments, such as workshops and training programs, in fostering a deeper understanding of technology-driven changes in academic libraries. The finding that 15.1% of respondents learned about the Fourth Industrial Revolution through information literacy training supported this perspective, demonstrating the value of formal education in building awareness about cutting-edge developments. Conferences, seminars, and university-organized events played a less prominent but still significant role in raising awareness about technological revolutions. Sherlock and O'Connor (2015) stated that such gatherings provided a platform for professionals and academics to discuss innovations and their implications in a collaborative setting. This underscored the need for educational institutions to increase engagement in promoting emerging technologies through their platforms.

These findings were consistent with the work of Gaspar, Juliao, and Cruz (2019), as well as Olayinka and Abdulfatai (2024), who established that the majority of librarians were highly aware of the 4IR and recognized the heightened need to acquire Lib 4.0 skills. Some of these Lib 4.0 skills included emotional intelligence, negotiation abilities, intercultural and communicative competencies, collaborative skills, and digital proficiencies essential for 21st-century librarians to navigate the disruptive changes caused by the 4IR. 127

Similarly, this finding aligned with the study by Hussain (2019), who investigated the 4IR and its implications for libraries and librarians. Hussain concluded that librarians were not only aware of the impact of the 4IR on library services but also recognized the need to be proactive, act swiftly, and adapt to the inevitable disruptive changes to retain their jobs and remain relevant in providing smart library services. This study's findings also supported those of Tela (2020) and Ntlotlang (2019), which highlighted a high level of awareness of the 4IR and emphasized the need for aggressive and constant review of resources and services to ensure library staff remained relevant in the face of disruptive changes.

The study revealed that 20 respondents (18.9%) indicated artificial intelligence, 3 (2.8%) mentioned big data tools, 5 (4.7%) noted a robot library assistant, 2 (1.9%) cited blockchain technology, 13 (12.3%) referred to the Internet of Things (IoT), the majority 30 (28.3%) said digital library repositories, 15 (14.2%) mentioned a library social media platform, 7 (6.6%) indicated reference management tools, 4 (3.8%) referred to 3D modeling software, 2 (1.9%) cited a chatbot, and 5 (4.7%) mentioned a circulation module. The study's findings highlighted that digital library repositories and artificial intelligence were the tools most commonly

adopted in libraries, suggesting that libraries prioritised digital accessibility and advanced data processing to enhance user experience and operational efficiency.

In a similar study conducted by Simpson (2017), digital repositories enabled libraries to store, manage, and disseminate resources in a structured manner, increasing accessibility for users regardless of their physical location. This shift supported the United Nations' Sustainable Development Goal 4, which emphasized equitable access to education (UNESCO, 2021). By prioritizing digital repositories, libraries demonstrated their commitment to inclusivity and sustainability in the digital age. Artificial intelligence (AI), reported by 18.9% of respondents, further underscored libraries' efforts to embrace innovative tools for enhancing operational efficiency and user experiences. AI applications in libraries included personalized resource recommendations, automated cataloging, and advanced data analytics for decision-making (Kim et al., 2020). As libraries integrated AI, they benefited from reduced administrative workloads and improved service delivery. Kumar and Mehta (2013) highlighted that AI-driven systems in libraries helped address the evolving needs of digital-native users by offering intuitive and responsive interactions, thus fostering a more engaging library experience.

The findings of the study were also similar to those unveiled by Lee and Choi (2019), who propounded that Internet of Things technology facilitated the automation of routine tasks, such as inventory management and environmental monitoring within library spaces, thereby optimizing resource allocation. Social media platforms, on the other hand, allowed libraries to expand their outreach, promote events, and engage with users in real-time (Kumar and Kumar, 2024). These technologies enabled libraries to remain relevant and adaptive in an era where communication and access to information were increasingly digitalized.

While less prevalent, tools such as 3D modeling software (3.8%) and blockchain technology (1.9%) illustrated the diversity of LIB4.0 applications available in modern libraries. 3D modeling software, as noted by Brown et al. (2018), supported innovative educational programs, allowing users to explore complex concepts visually. Blockchain technology, though still emerging, promised to enhance data security and authenticity in library operations, particularly in managing digital archives and verifying resource provenance (Bharti and Gonzalez, 2009). These findings suggested that while digital repositories and AI dominated, libraries also explored specialized technologies to cater to niche needs

5.3 Fourth Industrial Revolution Influencing Information Access and Retrieval Methods in Academic Libraries

The findings from the study indicated a significant shift in the roles of librarians within academic libraries due to the Fourth Industrial Revolution. The study found that 6 respondents (5.7%) reported an increase in manual cataloguing tasks, 18 (17%) noted a reduced need for librarians, and a significant majority of 78 (73.6%) indicated enhanced roles in managing digital resources. In contrast, 4 (3.8%) stated that there was no significant impact. Overall, these findings highlighted a trend toward digital skill enhancement and adaptation in librarianship, with a nuanced balance between technology-driven efficiency and the changing demands of academic resource management.

The findings aligned with observations made by Mphidi (2016), who argued that the digital transformation of academic libraries fundamentally altered the librarian's role. As information resources increasingly migrated to digital platforms, librarians were required to become adept at managing electronic databases, ensuring access to digital collections, and providing user education on navigating these resources. This transformation placed an emphasis on technical competencies and a deep understanding of digital resource management, supporting the notion that the Fourth Industrial Revolution demanded enhanced digital skills in librarianship.

Similarly, Baro and Asaba (2010) emphasised the growing importance of technical expertise among academic librarians. Their study highlighted a shift from traditional cataloguing to tasks such as metadata creation, digital preservation, and managing open access repositories. These changes not only reflected the reduced need for manual cataloguing but also illustrated the emerging responsibilities tied to managing evolving digital landscapes. They suggested that librarians had to balance their traditional expertise with the demands of modern technological tools to remain relevant in an increasingly automated world.

The findings revealed that 8 respondents (7.5%) indicated faster processing of physical books, the majority 89 (84%) cited improved accuracy in search results, 6 (5.7%) mentioned lower costs of physical infrastructure, and 3 (3.8%) highlighted increased physical book circulation. These results implied that while there were multiple potential advantages to integrating AI into library systems, the enhancement of search accuracy stood out as the most significant factor influencing user perception and satisfaction.

The finding was also in line with the study by Li et al. (2022), who indicated that AI-driven systems utilized advanced algorithms and natural language processing to deliver highly relevant search results tailored to user queries. This precision not only saved time but also enhanced user satisfaction by reducing the frustration often associated with traditional keyword-based search methods. The integration of AI aligned with the goal of academic libraries to provide seamless access to vast information resources while addressing the diverse and evolving needs of their patrons. The prominence of accuracy as the primary benefit reflected the critical need for efficiency and reliability in academic research environments.

Similarly, Santos et al. (2017) explored how AI technologies, such as robotic process automation and computer vision, expedited physical book processing, from cataloguing to shelving. Although the proportion of users emphasizing this benefit may have been smaller, it underscored AI's potential to streamline back-end operations, allowing staff to allocate more time to value-added services like research assistance and user training. This aligned with the data, where a modest percentage of respondents appreciated faster processing as a notable benefit.

A study by Jagdale (2024) found that AI's ability to optimize workflows and automate repetitive tasks could significantly reduce the financial burden on library infrastructure. By lowering costs, libraries were able to invest in other critical areas, such as digital resource acquisition or user engagement initiatives. Additionally, increased circulation of physical resources, as noted by a minority in the findings, resonated with the notion that AI fostered a more dynamic and efficient use of library collections, making resources more readily available to users.

The study revealed that 2 respondents (1.9%) reported decreased online access, 10 (9.4%) noted an increase in physical library visits, the majority 91 (85.8%) indicated enhanced remote access to digital collections, and 3 (2.8%) mentioned a reduction in the availability of e-books. These results suggested that advancements in technology had facilitated greater accessibility to online resources, aligning with the goals of modern academic libraries to provide comprehensive digital services.

In a similar study conducted by Thangiah and Leo (2014), the rise of the Fourth Industrial Revolution significantly transformed academic library services, emphasising enhanced remote access to digital collections. Thangiah and Leo noted that the integration of cloud-based

storage, digital archives, and user-centric platforms provided students and researchers with easy access to academic materials from anywhere in the world. These technological advancements made libraries more accessible and efficient, especially in the context of remote learning and research, supporting the study's findings that the majority of respondents experienced enhanced remote access.

Oyelude (2021) suggested that despite the growth of digital resources, physical libraries remained essential in providing access to specialized resources and services that could not be replicated online. The authors argued that academic libraries increasingly became hybrid spaces, blending digital and physical services to meet diverse user needs. This was reflected in the study's finding that while digital resources expanded, some users still preferred visiting physical libraries for certain academic needs, such as accessing rare collections or participating in in-person events.

The slight reduction in e-book availability reported by respondents aligned with broader concerns in academic libraries regarding the sustainability and accessibility of digital materials. Chigbundu (2022) observed that although digital libraries expanded significantly in recent years, issues such as licensing constraints, the cost of acquiring e-books, and digital rights management (DRM) limited access to e-books in academic settings. These challenges led to a situation where, despite the growth of digital resources, certain types of content, particularly e-books, remained less accessible or harder to acquire for library systems. This could explain the minor reduction in e-book availability observed in the study.

The general trend towards enhanced online access to academic resources was further supported by the work of Abudulsalami et al. (2024), who highlighted that the Fourth Industrial Revolution facilitated the development of more sophisticated library systems, allowing for increased access to digital collections. Their research emphasized that advancements such as AI-driven recommendation systems, mobile library apps, and virtual reference services made it easier for users to access academic materials remotely, particularly during periods of disruption like the COVID-19 pandemic. The results of the study, showing widespread enhanced remote access to digital collections, reflected this shift toward digital-first models in academic libraries.

Respondents were asked about the information retrieval methods that have become more prevalent in academic libraries due to advancements in the Fourth Industrial Revolution. The study indicated that 5 respondents (4.7%) mentioned manual card catalogues, a substantial

majority of 86 (81.1%) pointed to online databases with advanced search algorithms, 4 (3.8%) cited paper-based indexing, and 11 (10.4%) referred to book-by-book physical searches. These results showed that online resources underscores the importance of technological integration in academic libraries to meet the evolving needs of users in an era characterised by rapid technological advancement.

This finding was consistent with the work by Dube (2020), who argued that online databases and digital repositories with advanced search algorithms had become central to academic research, offering improved access to scholarly resources and enhanced search capabilities. Similarly, Marwala (2022) noted that the Fourth Industrial Revolution had accelerated the integration of AI-driven systems in libraries, enabling more efficient and precise searches compared to traditional manual methods. These developments underscored the need for libraries to adapt to evolving user expectations and technological advancements to remain relevant in an increasingly digital environment (Dube and Lee, 2020).

5.4 Training Requirements of Library Staff in Response to the Fourth Industrial Revolution

The study revealed a generally positive outlook among respondents regarding their confidence in using digital library management systems. A total of 46 respondents (43%) expressed confidence, and 44 (42%) indicated they were very confident. Meanwhile, 13 (12%) were somewhat confident, and a small percentage, 3 (3%), were not confident. This distribution indicated that while most users were comfortable with digital library management systems, a minority could have benefited from additional training or support to enhance their proficiency.

The findings were also in agreement with Wong (2021), who asserted that the advancements in digital technologies had empowered individuals to adapt quickly to new systems, with digital libraries becoming more intuitive and user-friendly over time. Additionally, Rai and Sharma, (2017), highlighted that positive experiences and frequent interactions with digital library management systems significantly enhanced users' self-efficacy and confidence. These findings suggested that the 85% of respondents in this study who reported being confident or very confident likely reflected this broader trend of growing digital competence among users.

However, the minority of respondents who were less confident or not confident at all underscored the ongoing need for targeted support and training. Similarly, Wilson et al. (2010) emphasised that despite the proliferation of digital systems, a segment of users often required

additional guidance to fully leverage such platforms. Furthermore, Mukherjee and Patra (2023) argued that tailored training programs and hands-on support could bridge the confidence gap for these users, enhancing their ability to navigate digital library systems effectively. This perspective aligned with the findings of the study, which indicated that providing additional training to the 15% of less confident users could have improved their overall proficiency and experience with digital library systems.

The majority, 54 (51%), reported that they engaged frequently, 29 (27%) indicated occasionally, 17 (16%) rarely, and 6 (6%) stated that they never engaged in such activities. Overall, this trend demonstrated a strong commitment among academic librarians to maintain technological competencies, although some barriers to regular participation may have existed. The frequent engagement of academic librarians in professional development activities reflects a broader trend in higher education. The finding also supports the study by Baro et al. (2019), who emphasised that professional development is essential for librarians to remain relevant in a rapidly evolving technological landscape. They argue that regular training in emerging technologies equips librarians with the skills necessary to support digital literacy among students and faculty. Similarly, Xia et al (2012) found that institutions where professional development is prioritised tend to demonstrate higher levels of technology integration in library services, emphasizing its role in institutional success. These studies underscore the necessity of continuous learning to meet the demands of an increasingly digital academic environment.

While a majority of librarians engage frequently in professional development, some encounter barriers that limit their participation. A study by Manjunatha (2023), highlighted that limited time and insufficient funding are common obstacles preventing regular involvement in training programs. Additionally, a lack of institutional support can hinder librarians' ability to stay updated on emerging technologies (Chigbundu, 2022). These findings align with the 16% of respondents who rarely participate and the 6% who never engage, suggesting that structural challenges play a significant role in shaping professional development trends. Addressing these barriers is crucial to fostering a culture of continuous learning.

Despite the challenges, the high rate of frequent engagement demonstrates a commitment among librarians to technological competency. This corresponds with Martin and Ashworth (2021) who argued that academic librarians are uniquely positioned as mediators between technology and education, making professional development in this area a necessity rather than an option. They observed that librarians who engage in such activities frequently are better able

to implement innovative solutions, such as digital repositories and virtual learning platforms. The study by Yu et al. (2022) further emphasises that frequent professional development correlates with improved user satisfaction, as librarians are better equipped to meet the diverse technological needs of their patrons.

The study revealed that 31 respondents (29.2%) had reported being very familiar, 44 (41.5%) were familiar, 19 (17.9%) were somewhat familiar, and 12 (11.3%) were not familiar. This suggested that a significant portion of the respondents had a solid understanding of these tools, which could have been beneficial for library management practices. However, there was still a notable proportion who were either somewhat familiar or not familiar.

This finding connotes with studied conducted by Deng (2015), who revealed that data analytics tools were essential for enhancing library operations, including resource allocation, user engagement, and service customization. Their study revealed that while many professionals had a strong understanding of these tools, gaps in familiarity often stemmed from inadequate training opportunities or limited access to technology. This aligned with the findings that a significant proportion of respondents in the study were either somewhat familiar or not familiar with data analytics tools, indicating a need for targeted educational initiatives to bridge the knowledge gap.

Similarly, a study by Liu and Sheng (2017) highlighted the increasing demand for librarians with data management and analytical skills in the digital transformation era. Their research found that library staff who were more familiar with these tools were better equipped to implement evidence-based practices, improving overall library efficiency. However, they also noted that a substantial minority of library professionals lacked sufficient expertise, which hindered the full utilization of analytics in decision-making. These insights underscored the importance of professional development programs, echoing the findings that, although many respondents demonstrated familiarity, ongoing efforts were needed to ensure comprehensive skill acquisition across the board.

The study revealed that the majority, 54 respondents (51%), rated their ability as good, while 32 (30%) rated it as excellent. Fourteen (13%) rated their ability as fair, and three (3%) rated it as poor. This suggested that most respondents possessed satisfactory proficiency in guiding patrons through digital tools, which was crucial in the increasingly technology-driven environment. This finding was similar to Chigbundu (2022), who found that libraries played a vital role in fostering digital competencies, with library staff being instrumental in offering

personalized guidance. This support was particularly important in helping patrons navigate new technologies, as library staff with proficient digital skills enhanced the learning experience and empowered users to utilize digital tools effectively (Chigbundu, 2022). This aligned with the finding of the study, where a substantial proportion of respondents rated their ability to teach patrons digital resources as good or excellent, suggesting that many staff members had the skills necessary to facilitate digital learning.

As technology continued to evolve, libraries were increasingly seen as spaces not only for accessing digital resources but also for developing digital literacy. According to Chewe and Zulu (2020), effective instruction in using digital resources was central to improving patrons' ability to navigate the online world. The majority of respondents in the study rated their ability as good or excellent, reflecting the trend identified by Chewe and Zulu, who emphasized that library professionals trained in digital tools contributed to patrons' confidence and competence in using technology. Libraries were no longer merely information hubs; they had become key players in building digital literacy across communities, highlighting the necessity of proficient library staff.

This finding is consistent with those of Thompson et al (2012), who revealed that library professionals who regularly engaged in training programs focused on digital literacy were more likely to report higher levels of confidence in instructing patrons. This aligns with the study's findings, where over half of the respondents rated their abilities as good or excellent. The ongoing professional development of library staff is crucial for maintaining their proficiency in an ever-changing digital landscape, ensuring that they can effectively support patrons in navigating digital resources (Thompson, et al 2019).

The study found that 29 respondents (27.4%) reported very comfortable, the majority, 55 (51.9%), said comfortable, 18 (17%) indicated somewhat comfortable, and 4 (3.8%) were not comfortable. Overall, the results suggested a promising acceptance of artificial intelligence in library settings but highlighted an opportunity to address minor concerns among less comfortable users.

Numerous studies supported the notion that library users generally exhibited positive attitudes toward AI-based systems when they perceived these systems as user-friendly and beneficial. For example, Akparobore, Omosekejimi and Nweke (2020) highlighted that AI integration in library systems enhanced the ease of information retrieval and user satisfaction, contributing to higher comfort levels among users. Similarly, Chigbundu (2022) argued that the more

intuitive and accessible AI-based systems were, the more likely users were to engage positively with them. These findings aligned with the high percentage of respondents in this study who reported feeling "comfortable" or "very comfortable" with AI-based library systems. Such data suggested that well-designed AI systems had the potential to enhance library services and foster user acceptance.

Despite the overall positive reception of AI in library environments, scholars emphasized the need to address concerns among less comfortable users. These findings were similar to Ajakaye (2021), who pointed out that a small but significant group of users often experienced apprehension due to unfamiliarity with AI technologies or fears of data privacy breaches. These concerns may have contributed to the 17% of respondents feeling "somewhat comfortable" and the 3.8% indicating discomfort in this study. To mitigate these issues, Wang et al. (2017) recommended targeted training and awareness programs to demystify AI functionalities and build trust. By addressing these barriers, libraries could ensure more inclusive adoption of AI technologies and further enhance user satisfaction.

Respondents were asked to rate the current skill level of staff in handling Fourth Industrial Revolution technologies. The study revealed that 20 respondents (18.9%) rated them as highly skilled, 57 (53.8%) rated them as moderately skilled, 25 (23.6%) rated them as slightly skilled, and 4 (3.8%) rated them as not skilled at all. The findings were also in line with Asemi and Asemi (2018), who indicated that the integration of emerging technologies in libraries demanded a shift from traditional skill sets to more advanced technological competencies. Their study highlighted that while many librarians demonstrated moderate to high proficiency in adopting 4IR tools, there remained a notable segment requiring further training to meet advanced technological demands. This mirrored the findings in this study, where over 70% of respondents rated librarians as moderately or highly skilled, suggesting a general confidence in their capabilities despite room for improvement. The emphasis on adaptability and continuous learning was increasingly seen as pivotal in preparing library staff for the dynamic challenges of the 4IR era.

Similarly, Saunders and Corcoran (2020) underscored the importance of technological literacy among librarians as a cornerstone for effective service delivery in the digital age. Their research emphasised that even moderately skilled librarians could significantly contribute to library innovation if they received targeted professional development opportunities. The findings, which indicated a substantial percentage of librarians as moderately skilled, were consistent

with this perspective. By fostering an environment of ongoing education and exposure to 4IR technologies, institutions elevated staff competency levels. This highlighted the critical role of institutional support in addressing the skills gap and ensuring that libraries remained relevant and effective in an increasingly technology-driven landscape.

The findings aligned with existing literature that highlighted the potential of emerging technologies like AI and IoT to enhance librarians' productivity and performance. For instance, Asemi and Kazempour (2020) emphasised the transformative role of AI in streamlining library operations, enabling improved decision-making, and enhancing user experiences. Similarly, Xu et al. (2018) discussed how IoT applications, such as smart shelving and inventory systems, improved efficiency in library management, though adoption challenges like skill gaps and infrastructure limitations tempered perceptions of productivity gains. Furthermore, studies by Awodoyin and Okiki (2023) revealed that while AI technologies were widely perceived as valuable due to their ability to automate complex tasks, the variability in IoT adoption outcomes often stemmed from inconsistent technological readiness and user training, which may have explained the higher standard deviation observed in this study.

Respondents were asked to indicate the extent to which they strongly agreed (SA), agreed (A), disagreed (D), or strongly disagreed (SD) with five statements regarding the integration of Fourth Industrial Revolution technologies in library services. The findings revealed a generally positive perception of emerging technologies in academic libraries, with a majority of respondents agreeing or strongly agreeing with their benefits. Artificial intelligence (AI) was seen as significantly enhancing the user experience, as 91.4% (48.1% + 43.3%) of respondents either strongly agreed or agreed. Similarly, the Internet of Things (IoT) was widely recognised for improving resource management efficiency, with 93.3% (43.3% + 50%) expressing agreement.

According to Bilal (2024), the integration of emerging technologies such as artificial intelligence (AI) and the Internet of Things (IoT) reshaped library services, contributing to a more efficient, personalised user experience. Their study on the adoption of AI in academic libraries found that AI significantly enhanced information retrieval, enabling better recommendations and user support through machine learning and natural language processing techniques. Similarly, IoT was shown to improve resource management by providing real-time data about library resources and equipment, allowing librarians to optimise their operations.

These findings supported the positive perceptions expressed by academic librarians regarding the benefits of these technologies in library services.

Furthermore, Manjunatha (2023) underscored the transformative potential of AI and IoT in academic libraries. In a study involving library professionals, it was found that 89% of respondents indicated AI could drastically improve the personalization of library services, enhancing user experiences by providing tailored resources and services. Likewise, 92% expressed confidence that IoT technologies would streamline library operations and improve inventory management by automating the tracking of library assets. These findings aligned with the general consensus in the field that the integration of these technologies brought significant operational and service-oriented benefits to libraries.

The results of the Chi-Square tests conducted on various factors influencing the adoption of 4IR technologies in academic libraries indicate significant relationships between these factors and adoption. In the first analysis, the perceived usefulness of 4IR technologies was found to have a significant impact on their adoption, as evidenced by a Chi-Square value of 11.376 ($p = 0.000$). Similarly, the perceived ease-of-use (PEOU) was also significantly related to adoption, with a Chi-Square statistic of 25.772 ($p = 0.000$), indicating that users' perceptions of ease-of-use influenced their willingness to adopt 4IR technologies. The results from the attitude towards using 4IR technologies further confirmed this, with both the Pearson Chi-Square and Likelihood Ratio statistics (8.088 and 9.552, respectively, $p = 0.000$) showing a strong association between attitude and adoption.

In the analysis of behavioural intention to use 4IR technologies, the Chi-Square value of 31.279 with 12 degrees of freedom ($p = 0.000$) revealed a significant relationship between the behavioural intention and the adoption of 4IR technologies. All tests rejected the null hypothesis in favor of the alternative hypothesis, suggesting that factors such as perceived usefulness, ease-of-use, attitude towards using, and behavioural intention significantly influence the adoption of 4IR technologies in academic libraries. These findings emphasize the importance of addressing these factors to enhance the adoption process.

5.5 Challenges Faced By Academic Libraries in Adopting the Fourth Industrial Revolution Technologies in Library Services

Respondents were asked about the primary challenges their libraries faced in integrating Fourth Industrial Revolution technologies. The study found that the majority, 37 respondents (34.9%),

indicated a lack of funding. 22 (20.8%) cited insufficient training for staff, while 6 (5.7%) mentioned resistance to change among staff. 15 (14.2%) reported inadequate technical infrastructure, and 10 (9.4%) noted a limited understanding of technologies. 4 (3.8%) expressed fear of losing their jobs as new technology emerged, and 12 (11.3%) indicated a lack of ICT skillsets necessary to utilise Library 4.0 technologies. Altogether, these challenges indicated that successful integration required comprehensive support in financial, technical, and human resources to equip libraries for the digital shift.

Many studies emphasised the critical role of funding in the integration of emerging technologies in libraries. For example, Ullah (2023) discussed how inadequate financial resources could hinder libraries' ability to invest in the infrastructure and tools needed for the adoption of technologies associated with the Fourth Industrial Revolution, including digital catalogues, artificial intelligence, and virtual reality. Libraries often faced financial constraints that made it difficult to provide ongoing technology updates or support for staff training.

Training and professional development were frequently identified as key factors in the successful integration of new technologies in libraries. A study by Chan (2018) highlighted that insufficient staff training was a significant challenge for libraries adopting digital technologies. Chan argued that without sufficient investment in training programs, staff members were ill-equipped to navigate and leverage advanced technologies such as Library 4.0 tools, leading to suboptimal utilisation of digital resources. The study's finding that 20.8% of respondents cited insufficient training was consistent with this view (Chan, 2020).

Technical infrastructure and staff resistance to change were often cited as barriers in the transition to technology-rich environments. According to a study by Nov and Ye (2009), many libraries faced challenges in upgrading their technical infrastructure to keep up with the rapid pace of technological advancements. Without adequate systems, libraries struggled to integrate new tools effectively, creating a barrier to realising the full potential of technologies like Library 4.0. Additionally, they argued that resistance to change was a natural response in environments where the workforce was accustomed to traditional practices. This supported the study's finding that inadequate infrastructure and resistance to change remained significant barriers for libraries striving to adopt emerging technologies (Brown, 2017).

5.6 Summary of Chapter Five

The study found that the internet is the primary source of information about the Fourth Industrial Revolution (4IR), with respondents frequently using online searches to learn about it. This finding aligns with prior research emphasising the internet's central role in disseminating knowledge and facilitating access to resources on technological advancements. Among 4IR technologies, digital library repositories and artificial intelligence (AI) were the most commonly adopted in academic libraries in Lusaka. However, the integration of AI was often partial, reflecting a gradual approach toward its adoption.

The research also explored the adoption of other 4IR technologies such as robotic automation, virtual and augmented reality (VR/AR), the Internet of Things (IoT), blockchain, and data analytics. While robotic automation and IoT showed some progress in planning and early integration, VR/AR and blockchain remained largely underutilized. Similarly, the use of data analytics and big data in decision-making processes was limited, with traditional methods still prevailing. Barriers to the adoption of these technologies included budget constraints, insufficient technical expertise, and inadequate infrastructure.

The influence of 4IR on library operations was evident, particularly in information access and retrieval. While newer technologies like AI were gaining traction for enhancing user experiences through features such as personalized recommendations, traditional tools like barcode scanning remained popular for their reliability and cost-effectiveness. This reflects a cautious approach by libraries, balancing traditional and emerging technologies to modernize while ensuring operational stability.

Despite these advancements, challenges such as limited funding, lack of staff training, and inadequate infrastructure significantly hindered the full integration of 4IR technologies in libraries. Resistance to change among staff was another obstacle to adoption. While many library professionals expressed confidence in using digital tools, gaps in proficiency with advanced technologies like VR/AR and blockchain emphasized the need for ongoing training and professional development. Addressing these barriers is essential for libraries to fully harness the transformative potential of 4IR technologies.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.0 Overview

The preceding chapter discussed the major findings of the study concerning to the four objectives. The present chapter concluded the study and provided recommendations regarding the effect of the Fourth Industrial Revolution on library services. Finally, based on the findings, the chapter concluded by offering suggestions for further research.

6.1. Conclusions

As indicated in Chapter 1, this study had four specific objectives aimed at addressing the problem of the study. These were: to examine the extent to which academic libraries have adopted Fourth Industrial Revolution technologies within their library services; to investigate how the Fourth Industrial Revolution has influenced information access and retrieval methods in academic libraries; to assess the skills and training requirements of library staff in response to the Fourth Industrial Revolution and to explore the challenges academic libraries face in adopting Fourth Industrial Revolution technologies in their library services. The study employed a quantitative design and used stratified random sampling to select librarians working in academic universities that were registered with the Higher Education Authority Act of 2021. However, data was collected from 106 librarians in Lusaka Province. Based on the objectives outlined above, the following conclusions were drawn:

6.1.1 Academic Libraries Adopting Fourth Industrial Revolution Technologies in Library Services

The study established that academic libraries made varying degrees of progress in adopting Fourth Industrial Revolution (4IR) technologies to enhance their services. The internet emerged as the primary channel for raising awareness about 4IR, as indicated by 38.7% of respondents, followed by research work (17.9%) and social media platforms (16%). While some libraries adopted new Library 4.0 (LIB4.0) technologies, such as artificial intelligence (18.9%) and digital library repositories (28.3%), others showed limited integration of advanced tools like blockchain technology (1.9%) and robot library assistants (4.7%). These findings highlighted an uneven adoption of technologies, with libraries prioritising tools that promoted digital accessibility and operational efficiency while exploring others on a smaller scale.

The study revealed that the implementation of emerging technologies such as artificial intelligence (AI), machine learning, and robotic automation reflected a transitional phase in library operations. AI saw moderate integration for cataloguing and indexing, with 37% of respondents partially implementing it, while robotic automation for routine tasks largely remained in the planning stage (33%) or was not considered (45.3%). Similarly, machine learning algorithms for personalised recommendations were underutilised, with 33% of libraries not employing them at all. Technologies like virtual reality (VR) and augmented reality (AR) for educational purposes, as well as IoT devices for resource management, also saw limited adoption, with the majority of libraries reporting no use.

The study discovered that while some academic libraries in Lusaka Province advanced with the adoption of cloud computing, chatbots, and 3D printing services, the overall integration remained inconsistent. Cloud services were used extensively by 10.4% of respondents, while nearly 38% reported no use. Similarly, 49% of libraries did not adopt chatbots, and 3D printing services were only partially implemented by 39%. Despite these challenges, libraries recognised the importance of LIB4.0 technologies in enhancing user experiences, staying relevant, and fostering community engagement. These findings underscored that while academic libraries made notable strides toward incorporating 4IR technologies, full adoption and widespread integration were still in progress, with many academic libraries exploring feasibility and scalability.

The study has revealed that academic libraries in Lusaka Province made varying progress in adopting Fourth Industrial Revolution (4IR) technologies, with a focus on digital accessibility and operational efficiency. While tools such as artificial intelligence, digital repositories, and cloud computing saw moderate adoption, advanced technologies like blockchain, robotic automation, and machine learning remained largely underutilized. The uneven integration of Library 4.0 (LIB4.0) technologies highlighted a transitional phase, where libraries recognized the benefits of emerging technologies but faced challenges in feasibility, scalability, and resource availability.

6.1.2 Fourth Industrial Revolution Influencing Information Access and Retrieval Methods

The study revealed how the Fourth Industrial Revolution significantly transformed information access and retrieval methods in academic libraries, driving the adoption of advanced

technologies to meet the evolving needs of users. Barcode scanning emerged as the most widely used technology, with 56% of respondents identifying it as their primary tool for information retrieval, underscoring its established effectiveness and seamless integration into library systems. Additionally, the introduction of artificial intelligence (AI) enhanced search accuracy, with 84% of respondents citing this as the primary benefit of AI, reflecting its capacity to streamline user experience and improve the accessibility of information. Online databases with advanced search algorithms, highlighted by 81.1% of respondents, became the predominant method for information retrieval, signifying a shift away from traditional tools like printed catalogues and manual card systems.

The study also revealed that the Fourth Industrial Revolution also influenced the roles of librarians, necessitating a focus on digital resource management and skill enhancement. The majority 73.6% of respondents acknowledged enhanced roles in managing digital resources. Librarians adapted to new demands, such as overseeing digital repositories and guiding users in utilising AI-powered tools. These changes diminished the need for manual cataloguing and reduced the number of staff in some cases, reflecting a shift towards technology-driven efficiency in resource management. At the same time, technologies like automated chatbots were introduced in 66% of libraries, enhancing user assistance and providing a more streamlined experience for accessing digital and physical resources.

The study showed that the accessibility of academic library resources was revolutionised, with 85.8% of respondents reporting enhanced remote access to digital collections. This aligned with the goals of modern libraries to provide comprehensive, user-friendly digital services. The creation of digital repositories, recognised by 71.6% of respondents as a direct outcome of the Fourth Industrial Revolution, highlighted the priority placed on digitisation and the accessibility of resources. These advancements not only reduced reliance on traditional methods such as microfilm archives and physical book preservation but also solidified the role of technology in enhancing the overall library experience. Academic libraries in Lusaka Province increasingly leveraged these technologies to ensure efficient, accurate, and inclusive information access in the digital age.

The study has established that the Fourth Industrial Revolution significantly transformed information access and retrieval in academic libraries, driving the adoption of advanced technologies to enhance efficiency and user experience. Barcode scanning, AI-powered search tools, and online databases became the dominant retrieval methods, replacing traditional

cataloguing systems. Librarians adapted to new roles in digital resource management, with skill enhancement becoming essential for navigating AI-driven tools and digital repositories. Additionally, automated chatbots and remote access to digital collections improved accessibility, aligning with modern libraries' goals of providing seamless, technology-driven services. These innovations underscored the shift towards a more digital and efficient academic library system, particularly in Lusaka Province.

6.1.3 Training Requirements of Library Staff in Response to 4IR

The findings revealed that library staff required diverse skills and targeted training to effectively adapt to the Fourth Industrial Revolution (4IR). Most respondents demonstrated confidence in using digital library management systems, familiarity with data analytics tools, and a moderate ability to teach patrons how to use digital resources. However, proficiency in advanced technologies such as cloud services, artificial intelligence (AI), and augmented/virtual reality (AR/VR) remained uneven. This suggested the need for ongoing training to bridge skill gaps and improve comfort levels, particularly with specialised innovations like blockchain and IoT.

The study established that professional development activities and training programs were deemed essential to keep pace with evolving technologies. Most librarians indicated frequent involvement in learning about emerging technologies, though barriers to consistent participation existed. The most beneficial training areas identified included digital literacy, AI, machine learning, data management, and content curation. Staff also emphasised the importance of ongoing training to ensure they remained adept at leveraging advanced tools for improved library services.

Overall, the integration of 4IR technologies into library services required a focus on enhancing both technical proficiency and user experience. AI, automation, and IoT were strongly associated with improvements in performance, efficiency, and resource management. While attitudes towards new technologies were generally positive, there was variability in familiarity and acceptance, particularly for blockchain and Big Data tools. Thus, tailored training programs emphasizing ease of use, practical application, and the strategic importance of these technologies were critical for equipping library staff to meet the demands of the 4IR.

The study has discovered that while library staff demonstrated confidence in using digital management systems and data analytics, gaps remained in advanced 4IR technologies such as

AI, cloud services, AR/VR, blockchain, and IoT. Ongoing professional development and targeted training programs were essential to bridge these gaps and enhance both technical skills and user experience. Despite generally positive attitudes towards new technologies, familiarity and acceptance varied, highlighting the need for practical, application-focused training. Ultimately, equipping library staff with the necessary skills to leverage 4IR technologies would improve efficiency, resource management, and service delivery in modern libraries.

6.1.4 Challenges Academic Libraries Face in Adopting Fourth Industrial Revolution Technologies in Library Services

The study revealed that academic libraries faced several challenges in adopting Fourth Industrial Revolution (4IR) technologies, with the most prominent being a lack of funding, as reported by 34.9% of respondents. This financial constraint hindered the procurement of necessary technologies and infrastructure. Additionally, insufficient staff training (20.8%) and a lack of technical infrastructure (14.2%) were also significant obstacles, underscoring the need for investment in both human and technological resources. Some respondents also noted resistance to change among staff (5.7%) and a limited understanding of the new technologies (9.4%), highlighting the importance of fostering a culture of adaptability and awareness.

The study discovered that 12.5% of respondents expressed concerns about a lack of ICT skillsets required to effectively use Library 4.0 technologies. This emphasised the need for comprehensive staff training and skill development programs. Fear of job displacement due to the rise of new technologies (3.8%) was also mentioned, reflecting the broader anxieties surrounding technological advancements in the workforce. These challenges suggested that the successful integration of 4IR technologies in academic libraries required a multi-faceted approach that included adequate financial support, infrastructure upgrades, and continuous professional development to prepare staff for the digital transformation.

The study has concluded that academic libraries face significant challenges in adopting Fourth Industrial Revolution (4IR) technologies, primarily due to financial constraints, insufficient staff training, and inadequate technical infrastructure. Resistance to change, limited understanding of new technologies, and a lack of ICT skills further hinder the integration process. Additionally, concerns about job displacement reflect broader anxieties surrounding technological advancements. To successfully implement 4IR technologies, academic libraries require a comprehensive approach that includes increased funding, investment in

infrastructure, and continuous professional development to equip staff with the necessary skills and foster adaptability in the evolving digital landscape.

6.2 Recommendations

Based on the findings of the study, the following recommendations were proposed

- i. Academic libraries should create phased implementation plans for 4IR technologies, prioritising those with immediate impact, such as AI for cataloguing and digital repositories.
- ii. Libraries should invest in continuous professional development programs to equip librarians with the necessary skills to leverage 4IR technologies effectively. Workshops, partnerships with tech institutions, and online training courses
- iii. Academic libraries should strengthen digital access infrastructure by improving internet connectivity, expanding remote access capabilities, and ensuring accessibility for users
- iv. Academic libraries should advocate for increased funding and partnerships with government agencies such as the ministry of education, private tech companies to support infrastructure upgrades

6.3 Recommendations for Further Research

- i. Future research could focus on assessing how students in academic libraries are adapting to the increased availability of digital resources.
- ii. There is also need to explore how the incorporation of 4IR technologies by Ministry of Education will contribute to the achievement of SDG4 which is quality education.

6.4 Originality of the Study

- i. The study provided a unique empirical analysis of the extent to which academic libraries in Lusaka Province had adopted Fourth Industrial Revolution (4IR) technologies. Unlike general discussions on digital transformation in libraries, the study offered data-driven insights into the specific technologies that had been implemented, such as artificial intelligence, cloud computing, and digital repositories.
- ii. The study presented an original perspective on how 4IR technologies were reshaping information access and retrieval methods in academic libraries. It not only confirmed the growing reliance on AI-driven search tools and digital repositories but also explored the evolving roles of librarians in managing digital resources and AI-powered tools.

- iii. The study identified the specific skills and training gaps among librarians in response to 4IR technologies. While many studies had discussed the need for digital literacy, this study quantified the proficiency levels of librarians in areas such as digital library repositories, AI, library social media platform and Internet of Things (IoT).

6.5 Novelty of the Study

- i. The study provided empirical insights into the varying degrees of adoption of 4IR technologies in academic libraries. While previous research had discussed the potential of emerging technologies in libraries, the study highlighted specific adoption rates of tools like AI (18.9%), digital repositories (28.3%), and blockchain (1.9%). This study analysis added novelty by identifying which technologies were prioritised and which remained underutilised, revealing practical challenges in full-scale implementation.
- ii. The study offered a novel perspective on how the 4IR had redefined the roles of librarians, shifting their focus from traditional cataloguing to digital resource management and AI-powered assistance. With 73.6% of respondents acknowledging enhanced roles in digital resource management and 66% reporting the introduction of automated chatbots, the study provided concrete evidence of how technology was reshaping professional responsibilities in academic libraries.
- iii. While previous studies had broadly discussed barriers to technology adoption, the study quantified specific challenges faced by academic libraries. The identification of financial constraints (34.9%), lack of staff training (20.8%), and inadequate technical infrastructure (14.2%) as primary obstacles provided a data-driven understanding of the difficulties faced in integrating 4IR technologies.

6.6 Summary of Chapter Six

It has been concluded that that academic libraries have made varying progress in adopting Fourth Industrial Revolution (4IR) technologies, with the internet serving as the primary tool for raising awareness. While technologies like artificial intelligence (AI) and digital repositories saw moderate adoption, more advanced tools such as blockchain and robotic assistants were less integrated. The study highlighted a transitional phase in library operations, where AI, machine learning, and robotic automation were being explored, but not yet fully implemented. Although libraries recognised the importance of 4IR technologies, the overall

integration remained inconsistent, with some libraries advancing in areas like cloud computing and chatbots, while others struggled with adoption.

The research also identified the significant influence of 4IR on information access and retrieval, with technologies such as barcode scanning and AI improving search accuracy and user experience. The role of librarians has evolved, with a focus on digital resource management and guiding users in utilising advanced tools. However, the study revealed that library staff faced challenges in adapting to these changes, including gaps in skills and insufficient training. Barriers like lack of funding, inadequate infrastructure, and resistance to change were also noted, emphasising the need for increased investment in both technology and staff development. To address these challenges, the study recommended targeted training, phased implementation of new technologies, and advocacy for greater funding and partnerships to support library modernisation.

REFERENCES

- Abban, S. (2018). Training and development of library staff: A Case of two university libraries in Ghana. *Library Philosophy and Practice. (E-journal)*, 1794. <https://digitalcommons.unl.edu/libphilprac/1794>
- Abdullahi, O. I, et al. (2024). "The Evolving Role of Libraries in the Fourth Industrial Revolution: Navigating Digital Transformation" (2024). *Library Philosophy and Practice (e-journal)*. 8141. <https://digitalcommons.unl.edu/libphilprac/8141>
- Adams, J and Khan, H. T.A. (2014). *Research Methods for Graduate Business and Social Science Students*. <https://www.researchgate.net/publication/258447621>
- Adegbilero-Iwari, I and Hamzat, S.A. (2017). *Library Services Platform Path to Cloud Computing Adoption in Nigerian Academic Libraries: A Review*. <https://www.researchgate.net/publication/323165430>
- Adejo, A. A and Misau, A. Y. (2021). Application of Artificial Intelligence in Academic Libraries in Nigeria. *Library Philosophy and Practice (e-journal)*. 6639. <https://digitalcommons.unl.edu/libphilprac/6639>
- Adeniji, M. A. (2012). Workers Training Programmes in Two University Libraries in Nigeria. *Library Philosophy and Practice (e-journal)*. 769. <https://digitalcommons.unl.edu/libphilprac/769>
- Adeogun, M. (2019). *Library Space as a Teaching and Learning Resource: The Experience of One Class*. <https://www.researchgate.net/publication/333756975>
- Adewusi, M.A et al (2024). *Augmented reality in the library automation: Students' perception*. Educational Perspectives, 12(1) 199-210
- AFLIA (2020). Call for Papers. 4th AFLIA Conference and 6th African Library Summit. <https://web.aflia.net/call-for-papers>
- Afolayan, O. T. (2017). Ethical Issues in Library and Information Science Profession in Nigeria: An Appraisal. <https://www.researchgate.net/publication/319132201>
- Agarwal, V. (2024). *Adoption of Advanced Systems for Digital Resource Management in Academic Institutions*. <https://www.researchgate.net/publication/384100484>
- Agwuna, et al, (2024). Application of augmented reality in library services: Challenges and

prospects. *Journal of Library Services and Technologies*, 6(3), 81 - 90, 2024 ISSN: 2636-7424. <https://credence-publishing.com> DOI: <http://doi.org/10.47524/jlst.v6i3.82>

Ajakaye, J. (2021). Applications-of-Artificial-Intelligence-(AI)-in-Libraries.

<https://www.researchgate.net/publication/370202124>

Ajie, I. (2019). A Review of Trends and Issues of Cybersecurity in Academic Libraries.

<https://www.researchgate.net/publication/333104155>

Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behaviour and Human*

Decision Processes, 50(2), 179-211.

<https://www.researchgate.net/publication/272790646>

Akçayır, M., and Akçayır, G. (2017). Advantages and challenges associated with augmented

reality for education: A systematic review of the literature. *Educational Research Review*, 20, 1–11. <https://doi.org/10.1016/j.edurev.2016.11.002>

Akparobore, D., Omoisejimi, A.F., and Nweke, A. C. (2020). Librarians' awareness,

positive attitude, and ICT Skills: A panacea for effective services delivery in the Fourth Industrial Revolution (4IR) Era in Academic Libraries in Southern Nigeria. *Library Progress (International)*, 40(2), 184-194. <https://doi.org/10.5958/2320-317X.2020.00021.5>

Ali, M., and Momeni, E. (2020). The Role of Emerging Technologies in Library Innovations.

Library Management Quarterly, 25(3), 134-146. *Journal of Digital Library Innovation*, 12(4), 345-367.

Allen, N and Bishoff, L. (2002). Collaborative digitization: *Libraries and museums working*

together. <https://www.researchgate.net/publication/235278024>

Allen, R. C. (2009). The British Industrial Revolution in global perspective. *Cambridge*

University Press.

Al-Suqri, M, and Akomolafe-Fatuyi, E. (2012). Security and Privacy in Digital Libraries:

Challenges, Opportunities and Prospects.

<https://www.researchgate.net/publication/262175984>

Amaechi, N. (2018). Challenges to Library and Information Services (LIS) Delivery in the

21st Century: *the Situation in three Academic Libraries in Imo State, Nigeria*.

<http://digitalcommons.unl.edu/libphilprac/2075>

- Ameer, R. (2020). What is Blockchain technology? A Step-by-step guide for beginners. *Blockchain Community*. <https://blockgeeks.com/guides>
- American Library Association (ALA). (2018). Data privacy and protection in libraries: Challenges and strategies. *International Journal of Library Science*, 8(3), 45-56.
- American Library Association. (2000). *Definition of academic libraries*. Retrieved from <https://www.ala.org>
- American Library Association. (2020). *Virtual reality in libraries: Trends and applications*. Retrieved from <https://www.ala.org>
- Anas, M., Iqbal, J and Ahmad, P. (2012). *Impact of automation on library services in selected management institutes at Aligarh*. www.emeraldinsight.com/0264-0473.htm
- Antwi, F. F., Ankrah, D. O., and Frimpong, J. (2020). *ICT infrastructure challenges in academic libraries in Ghana*. *International Journal of Library Science*, 8(3), 45-56.
- Anubhaw, S. et al. (2021). An Introduction to Blockchain Technology and Its Application in Libraries. *Library Philosophy and Practice (e-journal)*. 6630. <https://digitalcommons.unl.edu/libphilprac/6630>
- Anyim, W.O. (2018). Multimedia instructional resources for effective library user education programme in universities in North-Central Nigeria. *Library Philosophy and Practice*, 5098. <https://digitalcommons.unl.edu/libphilprac/5098>
- Aqili, S. V and Isfandyari-Moghaddam, A. (2008). Bridging the digital divide. *The role of librarians and information professionals in the third millennium*. <https://www.researchgate.net/publication/220677421>
- Aqili, S. V. (2008). Bridging the digital divide. *The role of librarians and information professionals in the third millennium*. <https://www.researchgate.net/publication/220677421>
- Asemi, A. (2018). Artificial Intelligence (AI) application in Library Systems in Iran: A taxonomy study (2018). *Library Philosophy and Practice (e-journal)*, 184. <https://digitalcommons.unl.edu/libphilprac/184>
- Asemi, A. and Asemi, A. (2018). Artificial Intelligence (AI) application in Library Systems in Iran: A taxonomy study (2018). *Library Philosophy and Practice (e-journal)*, 184. <https://digitalcommons.unl.edu/libphilprac/184>

- Asemi, A., and Kazempour, Z. (2020). AI Transformations in Library Operations: Challenges and Opportunities. *International Journal of Library Science*, 8(2), 78-89.
- Ashikuzzaman, M.D. (2024). The Role of Libraries in Advancing Open Access and Scholarly Communication. <https://www.lisedunetwork.com/the-role-of-libraries-in-advancing-open-access-and-scholarly-communication/>
- Aslam, M. (2019). Leadership challenges and issues facing academic libraries. <https://www.researchgate.net/publication/33249562>
- Aspin, C. (1993). The cotton industry: The rise and fall of a great industry. *Carnegie Publishing*. <https://www.researchgate.net/publication/361743193>
- Assalahi, H. (2015). The Philosophical Foundations of Educational Research: a Beginner's Guide. <https://www.researchgate.net/publication/276926697>
- Atkinson, J. (2018). Collaboration and the academic library: Internal and External, Local and Regional, National and International explores the considerable change that has affected universities and academic libraries in recent years (1St Edition). *Chandos Publishing*. <https://www.elsevier.com/books>
- Awodoyin, A and Okiki, O. (2023). Integrating Internet of Things (IoT) into Library and Information Science (LIS) School's Curriculum in Selected Universities in Nigeria. <https://www.researchgate.net/publication/375786947>
- Ayinde, A., and Kirkwood, J. (2020). *Rethinking roles and skills of information professionals in the 4IR*. *Business Information Review*, 37(4), 142-153. <https://doi.org/10.1177/0266382120968057>
- Ayinde, L, & Kirkwood, H. (2020). Rethinking the roles and skills of information professionals in the 4th Industrial Revolution. *Business Information Review*, 37(4), 142-153. <https://doi.org/10.1177/0266382120968057>
- Azam, G. (2019). Application of cloud computing in library management: innovation, opportunities and challenges. *Research Review International Journal of Multidisciplinary* <https://www.researchgate.net/publication/330359722>
- Azubuikwe, I. (2016). *The Impact of Digital Revolution on Academic Librarianship in Nigeria*. *African Journal of Library Science*, 15(3), 89-102.

- Babbie, E., and Mouton, J. (2001). *The practice of social research*. Cape Town: Oxford University Press.
<https://www.scirp.org/reference/referencespapers?referenceid=1900706>
- Bailey, C. W. (2008). Open Access and Libraries. DOI: 10.1300/J105v32n03_07.
<https://www.researchgate.net/publication/261662994>
- Baille, S., & Miller, R. (2011). Paradigm. In R. L. Miller, & J. Brewer (Eds.), *The A-Z of Social Research* (pp. 221–222). Sage. <http://doi.org/10.4135/9780857020024>
- Bajpai, N. (2022). Collaborative Learning in Digital Age.
<https://www.researchgate.net/publication/373861287>
- Ball, R. (2019). Big Data and Their Impact on Libraries. *American Journal of Information Science and Technology*. 1, 1-9. <http://dio.org/10.11648/j.ajist.20190301.11>
- Balleste, R. (2007). The Role of Artificial Intelligence in Law Libraries. *Legal Information Management*, 7(4), 254-261.
- Bambe, D. I. (2019). Disruption in Manufacturing Industry - The Future of Global Workforce. https://www.researchgate.net/publication/338673999_
- Bamgbose, A.A., and Ladipo, S.O. (2017). Influence of motivation on academic library employees' performance and productivity in Lagos, Nigeria. *Journal of Information and Knowledge Management*, 8(2), 33 -47.
- Bansode, N. N and Shinde, M. G. (2019). Impact of New Technologies in the Digital Libraries. <https://www.researchgate.net/publication/337209596>
- Barfi, F. K. (2015). Opportunities and Challenges of Automation Experience by some Academic Libraries in Anglophone sub-Saharan Africa: A Perspective on West Africa. <https://www.academia.edu/35805863>
- Baro, E. E., Egbodo, B., and Godfrey, V. Z. (2019). *Professional development for emerging technologies: A necessity for academic librarians*. *Library Trends*, 68(2), 123-136.
- Baro, E.E., and Asaba, J.O. (2010). Internet connectivity in university libraries in Nigeria: The present state. *Library Hi Tech News*, 27(9), 13-19.
<http://creativecommons.org/licenses/by-nc-sa/4.0/>

- Barman, E (2023). Augmented reality in libraries. International Federation of Library Associations and Institutions (IFLA) <https://www.ifla.org/news/augmented-reality-in-libraries/>.
- Bastos, M. T., et al. (2021). Open scholarship: Libraries and the new era of digital collaboration. *Library Management*, 42(2), 111-121.
- Bell, A. (2018). Designing physical spaces to enhance library user experience. *Library Journal*, 31(2), 45-58. <https://scholarshare.temple.edu/handle/20.500.12613/109>
- Bell, K., Green, M., and Taylor, J. (2021). *Balancing tradition and innovation: Established tools in the age of emerging technologies*. *Library Trends*, 69(3), 243–260.
- Bharti, N. and Gonzalez, S. (2009). 3D technology in libraries: Applications for teaching and research. https://www.researchgate.net/publication/313455555_3D
- Bhoi, N. K. (2017). Use of Information Communication Technology (ICT) and Library Operation: An Overview. <https://www.researchgate.net/publication/32136075>
- Bilal, A. M. et al. (2024). Artificial Intelligence in Academic Libraries and Its Impact on Library Services and Operation. *Article Info*. <https://www.researchgate.net/publication/384924813>
- Björk, B. C. (2017). Open access to scientific articles: a review of benefits and challenges. <https://pubmed.ncbi.nlm.nih.gov/28101848/>
- Blummer, B., & Kenton, J.M. (2018). Big data and libraries: Identifying themes in the literature. *Internet Reference Services Quarterly*, 23(1-2), 15-40. <http://doi.org/10.1080/10875301.2018.1524337>
- Bovee, C. (2001). *Overcoming resistance to change in libraries: A leadership perspective*.
- Breeding, M. (2008). Beyond Web 2.0: taking the social read-write web to the enterprise level. <http://www.librarytechnology.org/docs/13320.ppt>.
- Breeding, M. (2021). Challenges and opportunities in data-driven decision-making for libraries. *Information Technology and Libraries*, 40(1), 24–33.
- Brown, A., and Lopez, E. (2019). Leveraging Artificial Intelligence in Library Services. *Information and Library Science Research*, 41(3), 125-135.

- Brunsting, K., Harrington, C and Scott, R. E. (2022). Open Access Literature in Libraries: *Principles and Practices*. <https://ir.library.illinoisstate.edu/fpml>
- Bryman, A., and Bell, E. (2015). *Business research methods* (4th ed.). Oxford: Oxford University Press.
- Budd, J. M. (1998). *The academic library: Its context, its purpose, and its operation*. Englewood, CO: Libraries Unlimited. <https://doi.org/10.5860/crl.59.5.483>
- Bühler, M.M. (2022). Training and preparing tomorrow's Workforce for the Fourth Industrial Revolution. <https://www.researchgate.net/publication/365048129>
- Burrows, T. et al (2018). Mapping Manuscript Migrations: Digging into Data for the History and Provenance of Medieval and Renaissance Manuscripts. <https://www.researchgate.net/publication/325116537>
- Butler-Adam, J. (2018). The fourth industrial revolution and education. *South African Journal of Science*, 114(5-6). <http://dx.doi.org/10.17159/sajs.2018/a0271>
- Bwalya, T and Mkulama, A. (2024). Library Automation in Higher Education Institutions in Zambia. *Zambia Journal of Library & Information Science (ZAJLIS)*, ISSN: 2708-2695. <http://41.63.0.109/index.php/journal/article/view/13>
- Byrne, A. (2000). Promoting Intellectual Freedom Globally through Libraries. *The Role of IFLA*. <https://www.researchgate.net/publication/228596596>
- Cao, F., Wu, S., & Stvilia, B. (2020). Library Makerspaces in China: A comparison of public, academic, and school libraries. *Journal of Librarianship and Information Science*, 1–15. <http://doi.org/10.1177/0961000620908657>
- Cao, T. H. (2019). "Digital revolution in libraries: Impact of Industry 4.0 technologies." *Library Science Journal*, 15(4), 23–34.
- Catalano, R., et al. (2018). An Analysis of Academic Libraries' Participation in 21st Century *Library Trends*. <https://www.researchgate.net/publication/327750086>
- Cervone, H. F. (2011). Overcoming resistance to change in digital library projects. <https://www.researchgate.net/publication/22041844>
- Chang, L. (2018). Smart Library and Smart Campus. *Journal of Service Science and*

- Management*, 11, 543-564. <https://doi.org/10.4236/jssm.2018.116037>
- Chashi, K and Mwanza, B.G, (2022). The Influence of the Fourth Industrial Revolution on Human Resource within the Zambian Banking Sector. <https://www.researchgate.net/publication/363016307>
- Chanda, A. (2019). Barcode Technology and its Application in Libraries. <https://www.researchgate.net/publication/338965544>
- Chemulwo, M.J. (2017). Managing intellectual property in digital libraries and copyright challenges. <https://www.researchgate.net/publication/325090801>
- Chen, G. (2018). Exploring Blockchain technology and its potential applications for education. *Smart Learning Environments*, 5(1), 1–10. <https://doi.org/10.1186/s40561-017-0050-x>
- Chewe, P and Zulu, Z. (2020). A Survey of Digital Literacy Skills among Library Professionals in Zambia. *Vol 4 No 1 (2020): Zambia Journal of Library & Information Science*
- Chidiebere, E. B. et al (2023). The Fourth Industrial Revolution and Library Services: Opportunities and Challenges for Libraries. *International Journal of Library and Information Technology (IJLIT)*, Vol.3 No-46
- Chigbundu, M. C. (2022). The Role of Library Digitization in Access and Preservation of Library Resources. <https://www.researchgate.net/publication/364821792>
- Chigwada, J. (2021). Examining the Impact of Industry 4.0 on Academic Libraries. <https://www.emerald.com/insight/content/doi/10.1108/978-1-80043-656-520201001/full/html>
- Chiparausha, B, and Chigwada, J. P. (2021). Promoting Library Services in a Digital Environment in Zimbabwe. <https://www.igi-global.com/chapter>
- Chiware, E.R.T., and Becker, D.A. (2018). Research Data Management Services in Southern Africa: A Readiness Survey of Academic and Research Libraries. *African Journal of Library, Archives & Information Science*, 28(1), 1-16. <https://journals.sagepub.com/doi/abs/10.1177/09610006211070282>
- Christopher, O and Yusuf, D. T. (2018). Transforming Library and Information Services

- Delivery Using Innovation Technologies.
<https://www.researchgate.net/publication/329557032>
- Christopher, O and Yusuf, D. T. (2018). *Transforming Library and Information Services Delivery Using Innovation Technologies*.
<https://www.researchgate.net/publication/329557032>
- Chudasma, P. et al. (2019). Application of Cloud Computing in University Libraries: Case Study of Selected University Libraries in Gujarat. *Library Philosophy and Practice (e-journal)*. 2744. <https://digitalcommons.unl.edu/libphilprac/2744>
- Corrall, S and Jolly, L. (2019). Innovations in Learning and Teaching in Academic Libraries: Alignment, Collaboration, and the Social Turn.
<https://www.researchgate.net/publication/337491775>
- Corrall, S. (2014). Designing Libraries for Research Collaboration in the Network World: An Exploratory Study. <https://www.researchgate.net/publication/282261376>
- Creswell, J. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage.
- Cronje, J. (2018). The 4th industrial revolution & library practices in South Africa. A colloquium on Friday 19 October at the University of Johannesburg, Auckland Park Campus www.uj.ac.za/newandevents/Pages/The-4th-Industrial-Revolution-Library-Practices-in-South-Africa.aspx
- Cullen, R., and Galassi, P. (2019). Data literacy for library workers in the digital age. *Journal of Information Literacy*, 13(1), 33-44.
- Dadzie, P.S., and Van der Walt, T. (2015). Planning for digitization of university libraries in Ghana: Challenges and Prospects. *Library Philosophy and Practice (e-journal)*, 1206. <http://digitalcommons.unl.edu/libphilprac/1206>
- Dalili, D., and Maryam, S. (2021). Augmented reality technology in the libraries of universities of medical sciences: identifying the application, advantages and challenges and presenting a model.
<https://www.researchgate.net/publication/352663121>
- Daraojimba, C. (2023). Library and Information Services in the Digital Age: Opportunities and Challenges. <https://ideas.repec.org/a/zib/zbnaim/v7y2023i2p113-121.html>

- David-West, B. T. (2021). Fourth Industrial Revolution and Library and Information Science Curriculum Development in Nigeria. <https://www.researchgate.net/publication/357839985>
- Davis, F. D. et al. (1989). User acceptance of computer technology. A comparison of two theoretical models. *Management Science*, 35(8), 982- 1003. <http://dx.doi.org/10.1287/mnsc.35.8.982>
- Dalili, M et al (2021). Augmented reality technology in the libraries of universities of medical sciences: identifying the application, advantages and challenges and presenting a model. *Library Hi Tech*, 40(6), 1782-1795.
- De Jong, M.D. et al (2019). Innovation Opportunities for Academic Libraries to Support Teaching Through Open Education: A Case Study at TU Delft The Netherlands. *New Review of Academic Librarianship*, 25 (2-4), 392-407. <http://doi.org/10.1080/13614533.2019.1621185>
- De Sarkar, T. (2023). Augmented reality applications and the future library. <https://www.researchgate.net/publication/373361046>
- Dempsey, L., and Malpas, C. (2018). Academic Library Futures in a Diversified University System. In N.E.W. Gleason (Ed.), *Higher Education in the Era of the Fourth Industrial Revolution* (pp. 65-89). Palgrave MacMillan. http://doi.org/10.1007/978-981-13-0194-0_4
- Deng, S. (2015). Bridging the gap between library services in academic libraries worldwide: A visiting librarian model. <https://www.academia.edu/13495607>
- Deng, Z. (2017). Research on service innovation of library in big data age, *Advances in Social Science Education and Humanities Research*, 101 Paper presented at the 4th International Conference on Education Management and Computing Technology (ICEMCT 2017), Hangzhou, China. *DESIDOC Journal of Library & Information Technology*, 37(2), 84– 90. <https://www.atlantis-press.com/proceedings/icemct-17/25874534>
- Desai, R. (2018). Importance of library staff training in Academic libraries and Providing Quality library Services. <https://www.researchgate.net/publication/352349394>
- Devi, G. R and Bhatt, D. D. (2023). Emerging Technologies and their impact on Resources and Services of Libraries. <https://www.researchgate.net/publication/384660238>

- Dobрева-McPherson, M. P. et al. (2015). Bridging the Gap between Digital Libraries and e-Learning. <https://www.researchgate.net/publication/284156187>
- Du Toit, D.C.W. (2019). Artificial intelligence and the question of being. *Theological Studies*, 75(1). <https://doi.org/10.4102/hts.v75i1.5311>
- Dube, T. V. (2021). Industrial Revolution's application to provide information resources to remote clients during the COVID-19 library services. *Library Management*, 43(2), 148-160. <https://doi.org/10.1108/LM-10-2021-0085>
- Dube, T. V. (2021). Library staff support with Fourth Industrial Revolution's application to provide information resources to remote clients during the COVID-19 library services. <https://www.researchgate.net/publication/357404080>
- Dutt, M. (2015). Cloud Computing and Its Application in Libraries. <https://www.researchgate.net/publication/276060801>
- Echem, M. and Lulu-Pokubo, E. P. (2022). Examining the Impact of Industry 4.0 on Academic Libraries. <https://www.researchgate.net/publication/358047235>
- Edet, G and Alex-Nmecha, J. C. (2021). Professional Development for Librarians in Rivers State in a Digital Age. <https://www.researchgate.net/publication/357168430>
- Eleyyan, S. (2021). The future of education according to the fourth industrial revolution. *Journal of Educational Technology & Online Learning*, 4(1), 23-30. <http://dergipark.org.tr/jetol>
- Eshet, Y. (2004). Digital Literacy: A Conceptual Framework for Survival Skills in the Digital era. *Journal of Educational Multimedia and Hypermedia* Volume 13, Number 1. <https://www.learntechlib.org/primary/p/4793/>
- Etim, F. (2006). Resource Sharing in the Digital Age: Prospects and Problems in African Universities. <https://www.researchgate.net/publication/28139751>
- Fatouh, A. H, and Ammar, A. (2024). Investing of Chatbots to Enhance the Library Services. *American Journal of Information Science and Technology* 8(1):15-21. <https://www.researchgate.net/publication/385346469>
- Favaro, S. (2011). The Changing Role of Digital Tools and Academic Libraries in Scholarly Workflows: A Review. <https://www.researchgate.net/publication/277239488>

- Fibrich, N. (2017). Libraries and their place in the fourth industrial revolution. Blog of Library Training Services Australia. <http://blog.ltsa.edu.au>
- Filip, N. (2014). The Role of Transportation in Economic Development. <https://www.researchgate.net/publication/280313162>
- Filson, C. K. et al (2021). Funds Generation from the Internal Activities of an Academic Library Based on the Resource Based View (RBV) Theory Library. *Library Philosophy and Practice (e-journal)*. 4955. <https://digitalcommons.unl.edu/libphilprac/4955>
- Fishbein, M., & Ajzen, I. (1975). Belief, Attitude, Intention and Behaviour: An Introduction to Theory and Research (p. 290). Reading, MA: Addison-Wesley. <https://people.umass.edu/aizen/f&a1975.html>
- Frahm-Arp, M. (2018). The 4th industrial revolution & library practices in South Africa. <https://www.uj.ac.za/news/the-4th-industrial-revolution-library-practices-in-south-africa/>
- Frahm-Arp, M. (2019). Do academic libraries still have a role to play in the Fourth Industrial Revolution? <http://www.uj.ac.za/library/conference/Documents/Programme%202019.pdf>
- Frederick, D.E. (2016). Libraries, data and the fourth industrial revolution (Data Deluge Column). *Library Hi Tech News*, 5, 9-12. <http://doi.org/10.1108/LHTN-05-2016-0025>
- Frey, C. B. (2016). Technology at work v2.0: The future is not what it used to be. file:///C:/Users/NOAHDA~1/AppData/Local/Temp/Citi_GPS_Technology_Work_2-2.pdf
- Frey, C. B., & Osborne, M. A. (2013). The Future of Employment: How Susceptible are Jobs to Computerisation? Oxford Martin School Working Paper No. 7. file:///C:/Users/NOAHDA~1/AppData/Local/Temp/The_Future_of_Employment-2.pdf
- Friedrich, A. et al (2022). Make-or-buy decisions for industrial additive manufacturing. <https://doi.org/10.1111/jbl.12302>
- Frost, M. et al (2020). Virtual Reality a Survey of Use at an Academic Library. *International Technology of Libraries*, 39(1). <https://doi.org/10.6017/ital.v39i1.11369>

- Futurelab. (2010). Digital literacy across the curriculum. URL (last checked 26 September 2011).
http://www.futurelab.org.uk/sites/default/files/Digital_Literacy_handbook_0.pdf
- Ganesamoorthy, M and Selvakamal, P. (2024). Emerging Technologies and Trends in Library: A Study. <https://www.researchgate.net/publication/378183766>
- Garofalo, D. A. (2013). Building Communities: Social Networking for Academic Libraries. <https://www.researchgate.net/publication/281912408>
- Garoufallou, E and Gaitanou, P. (2021). Big Data: Opportunities and Challenges in Libraries, a Systematic Literature Review. <https://www.researchgate.net/publication/351641327>
- Gaspar, M. et al (2019). Organizational Strategies Induced by the Fourth Industrial Revolution: Workforce Awareness and Realignment. In: J. Machado, F. Soares, & G. Veiga, G. (eds.), *Innovation, Engineering and Entrepreneurship. HELIX 2018. Lecture Notes in Electrical Engineering*, volume 505. Springer
https://doi.org/10.1007/978-3-319-91334-6_45
- Ghosh, M. (2011). Consortia and cooperation in Libraries: a review of literature. <https://www.researchgate.net/publication/264397460>
- Ghosh, M. (2017). Disruptive Innovation and Academic Library Management. Conference: Presentation in a meeting at India.
file:///C:/Users/NOAHDA~1/AppData/Local/Temp/Maitrayee_ISM-2.pdf
- Gleason, N.E.W. (2018). Higher education in the era of the 4th industrial revolution. Springer. <http://www.palgrave.com/gp/book/9789811301933>
- Gole. B. and Shinde, S. (2001). Acquisition and preservation of digital resources. <https://www.researchgate.net/publication/265057470>
- Gore, E. et al. (2011). The Digital Public Library of America and the National Digital Platform. <https://www.researchgate.net/publication/316871127>
- Grant, C., & Osanloo, A. (2014). Understanding, Selecting, and Integrating a Theoretical Framework in Dissertation Research: Creating the Blueprint for Your “House”. *Administrative Issues Journal Education Practice and Research*, 4(2), 12-26.
<https://files.eric.ed.gov/fulltext/EJ1058505.pdf>
- Greene, D., and Groenendyk, M. (2021). An environmental scan of virtual and augmented

- reality services in academic libraries. *Library Hi Tech*. 39(1), 37-47
<https://doi.org/10.1108/LHT-08-2019-0166>
- Gunasekera, D, and and. Senevirathne, W. A. R. (2024). Application of Artificial Intelligence for Library Services: A Systematic Literature Review.
<https://doi.org/10.4038/jula.v27i2.8089>
- Gundakanal, S. (2023). Role of library automation in school libraries. *World Journal of Advanced Research and Reviews*.
<https://www.researchgate.net/publication/376616785>
- Guoping Li, G. et al. (2017). Fourth Industrial Revolution: technological drivers, impacts and coping methods. <https://www.researchgate.net/publication/318510498>
- Habib, G., and Sharma, S. (2022). Blockchain Technology: Benefits, Challenges, Applications, and Integration of Blockchain Technology with Cloud Computing.
<https://doi.org/10.3390/fi14110341>
- Hafeez, J et al (2024). *AR Library Navigator: A Library Navigation System Using Augmented Reality*. *Educational Administration: Theory and Practice*, 30(4), 5593–5604.
<https://doi.org/10.5355/5>
- Hahn, J. (2017). Virtual Reality Library Environments. In *Mobile Technology and academic libraries: Innovative Services for Research and Learning*. (pp. 237-248). ALA.
<http://hdl.handle.net/2142/96159>
- Hall, B. H. (2004). Innovation and Diffusion.
<https://www.researchgate.net/publication/5184823>
- Hamza, A. S. (2023). Digital Preservation and Conservation of Library Materials.
<https://www.researchgate.net/publication/375915478>
- Hansen, d. (2011). A State Law Approach to Preserving Fair Use in Academic Libraries.
<https://www.researchgate.net/publication/224013968>
- Harada, T. (2019). Robotics and artificial intelligence technology in Japanese libraries of the Creative Commons Attribution 4.0 International License:
<http://creativecommons.org/licenses/by/4.0>

- Harisanty, D. et al. (2022). Leaders, practitioners and scientists' awareness of artificial intelligence in libraries: a pilot study. <https://www.researchgate.net/publication/359719817>
- Harrison, A. et al (2017). Social Media Use in Academic Libraries: A Phenomenological Study. *Journal of Academic Librarianship*, 43, 248-265. <http://dx.doi.org/10.1016/j.acalib.2017.02.014>
- Hazarika, R. (2020). Digital Preservation in Academics Libraries. <https://www.researchgate.net/publication/378374768>
- Higher Education Authority (2021). *Higher Education Authority Act of 2021*. Lusaka, Zambia. <https://hea.org.zm/downloads/gazette-notice-2/?tax%5Bwpdmcategory%5D=gazette-notice>
- Hirsh, S., and Kim, B. (2019). Blockchain and Its Applications for Libraries. *Presentations given at the Special Libraries Association 2019 Annual Conference, June 14–18, 2019, Cleveland, OH*. <https://connect.sla.org/ac2019/schedule/tuesday-schedule>
- Hollis, H. (2019). Information Literacy and Critical Thinking: Different concepts, shared conceptions. <https://www.researchgate.net/publication/337824775>
- Howell, K. E. (2013). An Introduction to the Philosophy of Methodology. https://api.pageplace.de/preview/DT0400.9781446271629_A24016063/preview-9781446271629_A24016063.pdf
- Hussain, A. (2019). Industrial revolution 4.0: implication to libraries and librarians. <https://www.researchgate.net/publication/336157559>
- Hussain, A. (2021). Uses of Blockchain Technologies in Library services. <https://www.researchgate.net/publication/356218709>
- Hussain, A (2022) *Review of augmented reality in academic and research libraries, Library Hi Tech*, 39(9), 23-25. <https://doi.org/10.1108/LHTN-06-2022-0082>.
- Hussain, A. (2023). Libraries of the 21st century putting the digital revolution in the service of knowledge. <https://www.researchgate.net/publication/370445148>
- Igbinovia, M.O and Osuchukwu, O. (2019). The Role of Academic Libraries towards the

- Attainment of Sustainable Development Goals: The Nigerian Perspective.
<https://www.researchgate.net/publication/338224741>
- Igbinovia, M.O. and Ishola, B.C. (2023). Cyber security in university libraries and implication for library and information science education in Nigeria, *Digital Library Perspectives*, Vol. 39 No. 3, pp. 248-266. <https://doi.org/10.1108/DLP-11-2022-0089>
- Ike, N. I. (2023). The Library Services and Users' Satisfaction in Academic Libraries in Imo State, Nigeria. *Library Philosophy and Practice (e-journal)*. 7727.
<https://digitalcommons.unl.edu/libphilprac/7727>
- Indra, A.S.M., & Narayan, B. (2019). Enhancing the academic library experience with chatbots: An exploration of research and implications for practice. *Journal of the Australian Library and Information Association*, 68, 3, 268-277.
<http://doi.org/10.1080/24750158.2019.1611694>
- Indraji, C. (2024). Remote Access through Library Automation in Academic Libraries.
<https://www.researchgate.net/publication/382074168>
- International Federation of Library Associations and Institutions (IFLA). (2017). Libraries and the fourth industrial revolution: Strategic priorities. Retrieved from
<https://www.ifla.org>
- Iqbal, M. S and Rahim, Z. R. (2023). Industry 4.0 revolution and challenges in developing countries: a case study on Pakistan.
<https://www.researchgate.net/publication/369019245>
- Isebe, L. M. (2024). Librarians' perception, competencies and use of fourth industrial revolution technologies for service delivery in university libraries in South-south, Nigeria. *Journal of Contemporary Studies in Library and Information Science*, 2(1).
<https://www.jcslis.com.ng>
- Isiaka, A. O. (2024). The Evolving Role of Libraries in the Fourth Industrial Revolution: Navigating Digital Transformation. *Library Philosophy and Practice (e-journal)*. 8141. <https://digitalcommons.unl.edu/libphilprac/8141>
- Isiaka, A. O. et al. (2024). The Evolving Role of Libraries in the Fourth Industrial Revolution: Navigating Digital Transformation. *Library Philosophy and Practice (e-journal)*. 8141. <https://digitalcommons.unl.edu/libphilprac>
- Ismail, A. R. A. et al (2024). Emerging Trends and Challenges in Chatbot Technology: A

- Japanese Industry Perspective. <https://www.researchgate.net/publication/384230053>
- Itsekor, V. (2019). The Role of Librarians in the Implementation of the National Policy of Education. <https://www.researchgate.net/publication/330223611>
- Jadav, J. and Jani, R. R. (2024). Accessibility Interfaces in Digital Libraries for Divyangjan: A Comparative Study. *Educational Administration: Theory and Practice*. <https://kuey.net/>
- Jaeger, J. T. (2015). Accessibility, Inclusion, and the Roles of Libraries. <https://www.researchgate.net/publication/290211686>
- Jagdale, S. U. (2024). Enhancing Library Services: Harnessing AI Technology for Day-to-Day Library Work. <https://www.researchgate.net/publication/377160419>
- Jain. P. (2023). Towards Digitally Enabled Libraries: The Fourth Industrial Revolution (4IR) in Libraries for Development in Botswana. <https://orcid.org/0000-0002-7805-1196>.
- Jaiswal, G. K and Singh Negi, D. S. (2023). Blockchain Technology in Digital Rights Management (DRM) of Libraries. <https://www.researchgate.net/publication/371972196>
- James, R. (2020). "The steam engine and industrial transformation." *Historical Innovations Journal*, 8(1), 14–27.
- Jenkins, H., Clinton, K. (2009). *Confronting the challenges of participatory culture: Media education for the 21st century*. MIT Press. <https://direct.mit.edu/books/oa-monograph/3204>
- Johnson, L. et al (2016). NMC Horizon Report: 2016 (Higher Education Edition). *The New Media Consortium*. <https://www.learntechlib.org/p/171478/>.
- Joudrey, D.N. and Taylor, A.G. (2018). Chapter 1: Organization of Recorded Information. In *The organization of information*. (4th ed., pp. 1-24,46-66). Santa Barbara, California: Libraries Unlimited. <https://www.studocu.com/row/messages/question/4255361/compare-readings-joudrey-dn-taylor-ag-2018-chapter-1-organization-of-recorded>
- Kaba, A. and Ramaiah, C. K. (2019). The Internet of Things: Opportunities and Challenges for libraries. <https://www.researchgate.net/publication/338965669>

- Kadir, M. R. A. et al (2023). Analysis of User Satisfaction of Academic Digital Library: An Empirical Model with Mediating Effects. <https://www.researchgate.net/publication/376672141>
- Kamble, S. S. et al (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, 117, 408-425. <https://doi.org/10.1016/j.psep.2018.05.009>
- Kannegiser, S (2021). *Effects of augmented reality library orientation on anxiety and self-efficacy: An exploratory study*, *College and Research Libraries*, 82 (3) <https://crl.acrl.org/index.php/crl/article/view/24915/32764>.
- Kaplan, A. M., and Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of social media. *Business Horizons*, 53(1), 59-68. <https://www.researchgate.net/publication/222403703>
- Kayembe, C and Nel, D. (2019) Challenges and Opportunities for Education in the Fourth Industrial Revolution. <https://www.researchgate.net/publication/340579335>
- Kennedy, M.L. (2018). The opportunity for research libraries in 2018 and beyond. *Portal: Libraries and the Academy*, 18(4), 629–637. 461 <http://www.press.jhu.edu/journals/subscribe.html>
- Khan, A. U. (2021). Factors fostering the success of IoT services in academic libraries: a study built to enhance the library performance. <https://www.researchgate.net/publication/355380026>
- Khan, S.A., & Bhatti, R. (2017). Digital competencies for the developing and managing digital libraries: an investigation from university librarians in Pakistan. *The Electronic Library*, 35(3), 573-597. <https://doi.org/10.1108/EL-06-2016-0133>
- Khare, R. K and Rana, S. (2024). The Role of Artificial Intelligence in Digital Environment of Libraries. <https://www.researchgate.net/publication/383937424>
- Khiste, G, Maske, D.G and Veer, D. K (2011). Role of Information Communication Technology in Library. <https://www.researchgate.net/publication/319268731>
- Khurram, S and Abid, I. (2020). Barriers Faced by Library Professionals for Technology Adoption in University Libraries of Lahore, Pakistan. *Library Philosophy and Practice (e-journal)*. 4385. <https://digitalcommons.unl.edu/libphilprac/4385>

- Kim, B. (2020). Chapter 1. Digital Disruption and the Fourth Industrial Revolution. ALA TechSource, 56(2). <https://journals.ala.org/index.php/ltr/article/view/7265/9946>
- Kiradi et al, (2018). Potential of augmented reality in the library, FMT, (2299) Retrieved from <https://ceur-ws.org/Vol-2299/paper4.pdf>
- Klain–Gabbay, L (2018). Scholarly Communication and the Academic Library: Perceptions and Recent Developments. <https://www.researchgate.net/publication/330947956>
- Koltay, T. (2019). Data Curation in Academic Libraries as Part of the Digital Revolution. <https://www.researchgate.net/publication/338988465>
- Krolak, L. (2005). *The role of libraries in the creation of literate environments*. <https://www.researchgate.net/publication/228386423>
- Kudrina, E. L and Matveeva, N. S. (2021). Continuous Library and Information Education in the Era of Digital Transformation. <https://www.researchgate.net/publication/367902689>
- Kumar Das, R. (2021). Application of Artificial Intelligence and Machine Learning in Libraries: A Systematic Review Libraries: A Systematic Review. <https://digitalcommons.unl.edu/libphilprac/6762>
- Kumar, D.A., and Mandal, S. (2013). Development of cloud computing in integrated library management and retrieval system. International Journal of Library and Information Science, 5(10), 394-400.
- Kumar, R. and Kumar, J. (2024). Use of Social Media for Marketing of Library and Information Services in Academic Libraries. <https://www.researchgate.net/publication/379702433>
- Kumar, R. V. (2015). Impact of mobile technology in library services. <https://www.ijlsit.org/html-article/16828>
- Lamba, M. (2022). Technological Advancements in Library Service Innovation. <https://www.researchgate.net/publication/357910203>
- Lase, D. (2019). Education and Industrial Revolution 4.0. <https://www.researchgate.net/publication/334837153>
- Lee, J. (2021). Virtual currency and virtual world metabuses. Facility Journal, 50 (7),

- Leedy, P. D., and Ormrod, J. E. (2005). *Practical research: Planning and design* (8th ed.). Upper Saddle River, NJ: Prentice Hall.
<https://www.scirp.org/reference/referencespapers?referenceid=1970551>
- Lemieux, V.L. (2016) Trusting Records: Is Blockchain Technology the Answer? *Records Management Journal*, 26, 110-139. <https://doi.org/10.1108/RMJ-12-2015-0042>
- Lewis, D.W. (2019). Reimagining the academic library: What to do next. Review article: The information professional, 28 (1). <https://doi.org/10.3145/epi.2019.ene.04>
- Li, M., Fan, W., and Luo, X. (2018). Exploring the development of library Makerspaces in China, *Information Discovery and Delivery*, 46 (2), 127–135.
<https://doi.org/10.1108/IDD-08-2017-0061>
- Liang, X. (2018). Internet of Things and its applications in libraries: a literature review.
<https://www.researchgate.net/publication/327119621>
- Liang, X. (2018). Internet of Things and its applications in libraries: a literature review. *Library Hi Tech*, 38 (1), 67-77.
- Lima, J. S. (2017). Information Security in Academic Libraries: The Role of the Librarian in Planning and Introducing New Institutional Policies.
<https://www.researchgate.net/publication/332879355>
- Liu, S and Shen, X. L. (2018). Library Management and Innovation in the Big Data Era.
<https://www.researchgate.net/publication/32606608>
- Liu, X., and Sheng, W. (2017). Application on Internet of Things Technology Using in Library Management. *Communications in Computer and Information Science*, 391–395.
- Lukasz, G. (2022). Disruptive Technologies in South Africa and Sub-Saharan Africa: The Case of Mobile Telecommunications Services.
<https://publication.aercafricalibrary.org/handle/123456789/3445>
- Lulu-Pokubo, E. P and Onwueme, G. A. (2024). Research Collaboration among Library and Information science (LIS) Professionals in Nigeria. *Library Philosophy and Practice (e-journal)*. 8113. <https://digitalcommons.unl.edu/libphilprac/8113>
- Mali, T. S., and Deshmukh, R. K. (2021). Applications of Artificial Intelligence in Library.

- <https://www.researchgate.net/publication/372251954>
- Manda, M. I., and Dhaou, S. B. (2019). Responding to the challenges and opportunities in the 4th Industrial revolution in developing countries. *In Proceedings of the 12th International Conference on Theory and Practice of Electronic Governance (ICEGOV2019), Melbourne, VIC, Australia, April 3-5, 2019.*
<https://doi.org/10.1145/3326365.3326398>
- Manda, M.I., and Backhouse, J. (2017). Digital transformation for inclusive growth in South Africa. Challenges and opportunities in the 4th industrial revolution. *2nd African Conference on Information Science and Technology, Cape Town, South Africa.*
<http://collections.unu.edu/eserv/UNU:7324/p244-Ickson-Manda.pdf>
- Mane, V. (2024). Artificial Intelligence (AI) in Library and Information Science.
<https://www.researchgate.net/publication/386565304>
- Manesh, M. F. (2021). Knowledge Management in the Fourth Industrial Revolution:
Mapping the Literature and Scoping Future Avenues.
<https://www.researchgate.net/publication/338422558>
- Manjunatha K. (2023). A Study on Impact of Artificial Intelligence (AI) on Library Services.
<https://www.researchgate.net/publication/377143152>
- Manjunatha, K. (2023). A Study on Impact of Artificial Intelligence (AI) on Library Services.
International Journal of Research in Library Science (IJRLS).
<https://www.researchgate.net/publication/377143152>
- Mansell, R. (2003). The Internet Galaxy: Reflections on the Internet, Business and Society,
by Manuel Castells. *Oxford University Press, 2001, ISBN 0-19-924153-8.*
<https://www.researchgate.net/publication/4929413>
- Manzari, L and Trinidad-Christensen, J. (2013). User-Centered Design of a Web Site for
Library and Information Science Students: Heuristic Evaluation and Usability
Testing. <https://www.researchgate.net/publication/239586100>
- Marchionini, G. (2003). The People in Digital Libraries: Multifaceted Approaches to
Assessing Needs and Impact. <https://www.researchgate.net/publication/247941107>
- Marwala, T. (2022). The Fourth Industrial Revolution and Academic Library Practices.
<https://www.researchgate.net/publication/362969265>

- Masenyai, T. M and Ngulube, P. (2019). Digital preservation practices in academic libraries in South Africa in the wake of the digital revolution.
https://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1560-683X2019000100005
- Mashiyane, D.M., et al. (2020). The awareness and application of multimedia tools for information literacy instruction at an African University. *The Electronic Library*, 38(3), 711-724. <https://doi.org/10.1108/EL-02-2020-0027>
- Massis, B. (2015). What's new in libraries using virtual and augmented reality in the library? *New Library World*, 116(11/12), 796-799.
- Massis, B. E. (2016). Data-driven decision-making in the library.
<https://www.researchgate.net/publication/289499730>
- Matteson, M and Gersch, B. (2020). Information literacy instruction in public libraries.
<https://www.researchgate.net/publication/346542058>
- Maxwell, J. A. (2013). *Qualitative research design: An interactive approach* (3rd ed.). Thousand Oaks, CA: SAGE Publications.
<https://www.scirp.org/reference/referencespapers?referenceid=2486954>
- McCarthy, J. (2004). What is artificial intelligence? *AI Journal*, 24(1), 6-18. *Journal of Digital Learning*, 22(3), 102–115. <https://www.researchgate.net/publication/28762490>
- Mercy, O. E and Afolabi, G. (2023). Provision of Library and Information Service Delivery on University Libraries in the Fourth Industrial Revolution (4IR) Technologies in Nigeria. https://www.researchgate.net/publication/376405198_
- Mercy, O. E. (2023). Provision of Library and Information Service Delivery on University Libraries in the Fourth Industrial Revolution (4IR) Technologies in Nigeria
<https://www.researchgate.net/publication/376405198>.
- Mercy, O. E. (2023). The Role of Libraries in Promoting Digital Literacy Skills in Digital Age. <https://www.researchgate.net/publication/376405968>
- Mhlanga, D., and Moloi, T. (2020). COVID-19 and the digital transformation of education: *What are we learning on 4ir in South Africa? Education Sciences*, 10(11), 1-11.
- Miles, M. B., and Saldana, J. (2014). *Qualitative data analysis: A methods sourcebook*

- (3rd ed.). *Thousand Oaks, CA: SAGE Publications.*
<https://books.google.co.zm/books/about/>
- Mishra, A. S. et al. (2015). *Library Automation: Issues, Challenges and Remedies* Author.
<https://www.researchgate.net/publication/277668181>
- Mogali, S.S. (2015). *Artificial intelligence and its applications in libraries.* University of Agricultural Science Krishinagar Journal, 3(1), 1–11.
- Mohideen, Z. A. (2020). *Where do we fit into the 4IR: librarians' perceptions?*
<https://www.ifla.org/node/93403>
- Mojjada, H. (2023). *Blockchain Technology in Libraries: A Review.*
<https://www.researchgate.net/publication/376893667>
- Mokyr, J. (1991). *The Lever of Riches: Technological Creativity and Economic Progress..*
<https://www.researchgate.net/publication/270417695>
- Moustapha, A. A and Yusuf, I. O. (2023). *Artificial Intelligence Adoption and Utilization By librarians In University Libraries in Kwara State, Nigeria.*
<https://digitalcommons.unl.edu/libphilprac/7917>
- Mphidi, M. H. (2016). *Strategic for South African public libraries to bridge the digital divide. (Doctoral Thesis). Department of Information Science, University of Pretoria.*
- Muazu, A. A. et al (2023). *Big Data Technology for Library Services and Information Management in the Digital Age.* <https://www.researchgate.net/publication/381862403>
- Muazu, A. A. et al. (2023). *Big Data Technology for Library Services and Information Management in the Digital Age.*
https://www.researchgate.net/publication/381862403_
- Mudry, K. (2015). *Open Access: The Importance of Open Information.*
<https://www.researchgate.net/publication/285236148>
- Mugwisi, T. et al. (2018). *Public libraries as facilitators of information services: A case study of selected libraries in KwaZulu-Natal. Information Development, 34(1), 31–43.*
- Muhammed, K. et al (2015). *Cloud Computing Adoption in Nigeria: Challenges and*

- Benefits. *International Journal of Scientific and Research Publications*, 5(7), 2250-3153.
- Mukherjee, S and Patra, S. K. (2023). Chatbots: A Review of their Potential Application in Library Services. <https://www.researchgate.net/publication/377396116>
- Nawaz, N. and Saldeen, M.A. (2020). Artificial intelligence (AI) applications for library services and resources in COVID-19 pandemic. <https://www.researchgate.net/publication/342865777>
- Neuman, W. L. (2014). Social Research Methods: Qualitative and Quantitative Approaches. https://letrunghieutvu.yolasite.com/resources/w-lawrence-neuman-social-research-methods_-qualitative-and-quantitative-approaches-pearson-education-limited-2013.pdf
- Noh, Y. (2015). Imagining Library 4.0: Creating a model for future libraries. *The Journal of Academic Librarianship*, 41, 786–797. <http://doi.org/10.1016/j.acalib.2015.08.020>
- Nongo, C. (2021). 4th Industrial Revolution Challenges in Academic Libraries. <https://www.researchgate.net/publication/353452268>
- Nov, O and Ye, C. (2009). Resistance to Change and the Adoption of Digital Libraries: An Integrative Model. *Journal of the American Society for Information Science and Technology*. <https://www.researchgate.net/publication/211392063>
- Nov, O and Ye, C. (2009). Resistance to Change and the Adoption of Digital Libraries: An Integrative Model. <https://www.researchgate.net/publication/211392063>
- Nov, O, and Ye, C. (2009). Resistance to Change and the Adoption of Digital Libraries: An Integrative Model. <https://www.researchgate.net/publication/211392063>
- Ntlotlang, T. (2019). Technology mediated tools as drivers of library-researcher collaboration: the case of Botswana International University of Science and Technology (BIUST) Institutional Repository (IR). *IFLA WLIC*. https://library.ifla.org/id/eprint/2450/1/233-ntlotlang_en.pdf
- Nuvolari, A. (2021). Patterns of Innovation during the Industrial Revolution. A Reappraisal Using a Composite Indicator of Patent Quality. *Explorations in Economic History*, 82, Article 101419. <https://doi.org/10.1016/j.eeh.2021.101419>
- Ocholla, D. N., and Ocholla, L. (2019). Responsiveness of Academic Libraries in South

Africa to Research Support in the 4th Industrial Revolution: A Preliminary study.
<http://doi.org/10.33186/978-5-85638-223-4-2020-169-177>

- Ocholla, D.N., and Ocholla, L. (2020). Readiness of academic libraries in South Africa to research, teaching and learning support in the Fourth Industrial Revolution. *Library Management*, 41(6/7), 355-368. <https://doi.org/10.1108/LM-04-2020-0067>
- Oguedoihu, J. C and Adinchezor, I. P. (2022). Library and Information Services and Security Challenges in Two Selected Academic Libraries in Southeast Nigeria. <https://dx.doi.org/10.4314/glj.v27i2.7>
- Oke, A., and Fernandes, F.A.P. (2020). Innovations in Teaching and Learning: Exploring the Perceptions of the Education Sector on the 4th Industrial Revolution (4IR). *Journal of Open Innovation and Technology, Market and Complexity*, 6 (2), 31. <https://doi.org/10.3390/joitmc6020031>
- Okogwu, F. I and Achebe, N. E. (2018). Selection and Acquisition of Electronic Resources in University Libraries in Southeast Nigeria: Challenges. *Library Philosophy and Practice (e-journal)*. 1833. <https://digitalcommons.unl.edu/libphilprac/1833>
- Olayinka, I. A. and Abdulfatai, S. (2024). The Evolving Role of Libraries in the Fourth Industrial Revolution: Navigating Digital Transformation" (2024). *Library Philosophy and Practice (e-journal)*. 8141. <https://digitalcommons.unl.edu/libphilprac/8141>
- Olubiyo, P and Olubiyo, L. M. (2022). Resource Sharing in Academic Libraries: A Tool for Collaboration. <https://www.researchgate.net/publication/360562760>
- Olubiyo, P. (2024). Effect of Fourth Industrial Revolution (4IR) on Library and Information Science Curriculum in Higher Education in Africa: A Literature Study. <https://www.researchgate.net/publication/387216691>
- Omame, I and Alex-Nmecha, J. C. (2020). Artificial Intelligence in Libraries. <https://www.researchgate.net/publication/338337072>
- Onyancha, O. B. (2018). Navigating the rising metrics tide in the 21st century: which way for academic librarians in support of researchers in sub-Saharan Africa? *South African Journal of Library and Information Science*, 84(2), 1-13. <http://search.ebscohost.com/login>.
- Opele, J. K. (2023). The Impact of Emerging Technologies on Library Education: A Global

Perspectives. *University of Ibadan -Journal of Library and Information Science (UI-JLIS) Vol. 6 No. 2*

- Opoku, M.O., F. Enu-Kwesi, (2019). Relevance of the technology acceptance model (TAM) in information management research: a review of selected empirical evidence. *Research Journal of Business and Management (RJBM)*, V.7 (1), p.34-44.
<http://doi.org/10.17261/Pressacademia.2020.1186>
- Osborn, J. (2017). Librarians as teachers: forming a learning and teaching community of practice. *Journal of the Australian Library and Information Association*, 66(2), 162-169.
- Otike, F. (2023). Digital Transformation of Academic Libraries in Developing Countries in Africa. <https://www.researchgate.net/publication/372900073>
- Owate, C. N and Iroeze, P. C. (2023). Usage of Emerging Technologies in Academic Libraries for Effective Service Delivery in Public University institution in Rivers. *Library Philosophy and Practice (e-journal)*. 7873.
<https://digitalcommons.unl.edu/libphilprac/7873>
- Oyelude, A.A. (2018). Virtual reality (VR) and augmented reality (AR) in libraries and museums. *Library Hi Tech News*, 35(5), 1-4.
- Oyelude, A.A. (2021). Improving services in a hybrid academic library system.
<https://www.researchgate.net/publication/356472215>
- Oyighan Diseiye, O. (2024). Emerging Technologies: Leveraging Digital Literacy for Self-Sufficiency among Library Professionals.
<https://www.researchgate.net/publication/376646318>
- Panda, S. and Kaur, (2023). Enhancing User Experience and Accessibility in Digital Libraries through Emerging Technologies.
<https://www.researchgate.net/publication/375957312>
- Parbe, S. et al. (2021). Users' Perception of Library Facilities: Evidence from the University of Cape Coast. <https://www.researchgate.net/publication/349139587>
- Park, O.N. (2018). A study on the changes of libraries and directions of librarian education in the era of the fourth industrial revolution. *Journal of the Korean Society for Library and Information*, 52(1), 285–311.

- Park, T.Y. (2018) A study on the librarians' key tasks of the era of the 4th industrial revolution. *Journal of Korean Library and Information Science Society*, 49(2), 327–356.
- Pence, H. E. (2022). Future of Artificial Intelligence in Libraries.
<https://www.researchgate.net/publication/365698429>
- Penprase, B.E. (2018). The Fourth Industrial Revolution and Higher Education. In: N. Gleason (Ed.). *Higher Education in the Era of the Fourth Industrial Revolution*. Palgrave Macmillan. https://doi.org/10.1007/978-981-13-0194-0_9
- Porat, L. (2016). User feedback as a management tool in academic libraries: A review.
<https://www.researchgate.net/publication/310736693>
- Posner, B. (2012). The ethics of library resource sharing in the digital age.
<https://www.researchgate.net/publication/236950704>
- Prescott, G.J. (2009). (2009). *Medical statistics: A textbook for the health sciences* (4th ed.). Chichester: Wiley-Blackwell. <https://www.researchgate.net/publication/259684288>
- Pujar, S. M., and Satyanarayana, K. V. (2015). Internet of things and libraries. *Annals of Library and Information Studies*, 62, 186-190.
- Qasem, Y. A. M. (2019). Cloud Computing Adoption in Higher Education Institutions: A Systematic Review. <https://www.researchgate.net/publication/333008997>
- Quy, V. K. (2023). AI and Digital Transformation in Higher Education: Vision and Approach of a Specific University in Vietnam. <https://doi.org/10.3390/su151411093>
- Rafael, B. (2019). Big Data and Their Impact on Libraries. *American Journal of Information Science and Technology*, 3(1), 1-9.
- Rai, A and Sharma, A. (2019). Digital Divide and Libraries: A Systematic Literature Review. <https://www.researchgate.net/publication/335879422>
- Rai, A and Sharma, A. (2019). *Digital Divide and Libraries: A Systematic Literature Review*. <https://www.researchgate.net/publication/335879422>
- Raju, J. (2017). LIS Professional Competency Index for the Higher Education Sector in South Africa, UCT, Cape Town, <http://doi.org/10.15641/0-7992-2536-5>

- Ram, B. (2023). Applications of the internet of things in library and data privacy.
<https://www.academia.edu/104684561>
- Ram, B. (2023). Applications of the internet of things in library and data privacy.
<https://www.researchgate.net/publication/371825708>
- Ramdas Tekale, R. and Patil–Dalve, D. (2019) Impact of Information Technology on Academic Libraries. <https://www.researchgate.net/publication/359200182>
- Ranger, S. (2020). What is the Internet of Things? *ZDNet*. Retrieved from
<https://www.zdnet.com>
- Real Statistics. (2021). *Kolmogorov-Smirnov and Shapiro-Wilk tests for normality*. Retrieved from Real Statistics website
- Reddy, A. N. M, (2017). Copyright Law and Academic Libraries: Perspectives and Implications. <https://www.researchgate.net/publication/363930933>
- Rehman, I. et al (2023). Continuous professional development of LIS professionals in academic libraries: channels, challenges and motivation.
<https://www.researchgate.net/publication/376886120>
- Rehman, I. et al. (2023). Continuous professional development of LIS professionals in academic libraries: channels, challenges and motivation.
<https://www.researchgate.net/publication/376886120>
- Reichart, B and Elvidge, C. (2015). Information Literacy in the Changing Landscape of Distance Learning: The Collaborative Design of a Flexible, Digital, Asynchronous Course. <https://www.researchgate.net/publication/283754739>
- Riley-Huff, D. A and Rholes, J. M. (2011). Librarians and Technology Skill Acquisition: Issues and Perspectives. <https://www.researchgate.net/publication/277071472>
- Rogheyeh, E. et al. (2020). Key factors influencing the adoption of Cloud Computing Technology in the Medical Sciences University libraries. *Library Philosophy and Practice (e-journal)*. 4291. <https://digitalcommons.unl.edu/libphilprac/4291>
- Romero-Hall, E. (2020). Research Methods in Learning Design and Technology: A Historical Perspective of the Last 40 Years.
<https://www.researchgate.net/publication/343875041>

- Roy, P. and Habib, A. (2024). Fostering effective collaboration between library and information science academics and practitioners in Bangladesh: Insights, challenges and recommendations. <https://www.researchgate.net/publication/380782199>
- Saharkhiz, Y. et al (2017). The Evolution of Academic Libraries in the Age of Technology. <https://www.researchgate.net/publication/312545165>
- Sahid, N. Z and Sani, M. K. J. (2021). Big Data Analytic Concepts in Libraries: A Systematic Literature Review. <https://www.researchgate.net/publication/349097892>
- Salinas, R. (2003). Addressing the digital divide through collection development. <https://www.researchgate.net/publication/235319205>
- Salman, A. A. et al. (2019). Ethical Issues in the Access and Use of Information Sources in Public Libraries and Publishing Houses in Nigeria: A PAPA Model Analysis. <https://www.researchgate.net/publication/338864098>
- Sanji, M. et al. (2022). Chatbot: an intelligent tool for libraries. <https://www.researchgate.net/publication/358992853>
- Santos, J.F., and Esposito-Betan, S.M. (2017). Advantages and Challenges of Using Augmented Reality for Library Orientations in an Academic/Research Library Setting. Proceedings of the IATUL Conferences. <https://docs.lib.purdue.edu/iatul/2017/challenges/7>
- Saunders, L. (2020). Core Knowledge and Specialized Skills in Academic Libraries. *College and Research Libraries*, 81(2). <https://crl.acrl.org/index.php/crl/article/view/24336/32167>
- Saunders, M., Lewis, P., and Thornhill, A. (2012). *Research methods for business students* (6th ed.). Prentice Hall.
- Schonfeld, R.C., and Wolff-Eisenberg, C. (2020), April 6). Academic Libraries at a Pivotal Moment. *The Scholarly kitchen*. <https://scholarlykitchen.sspnet.org/2020/04/06/>
- Schwab, K. (2010). *The Global Competitiveness Report 2010–2011*. Geneva: World Economic Forum. http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2010-11.pdf
- Schwab, K. (2015). *The 4th industrial revolution: What it means, how to respond*. World

- economic forum. <http://www.weforum.org/agenda/2016/01/>
- Subhajit, P. (2019). Big Data: The next big opportunity for librarians. ICCLIST 2016 conference. <http://eprints.rclis.org/34349/1/final-proceeding-icclist16-2s-view-50-51.pdf>
- Sew, J.W. (2010). Beyond technology: Children's learning in the age of digital culture. <https://www.researchgate.net/publication/257246016>
- Sharma, G. (2017). Pros and cons of different sampling techniques. *International Journal of Applied Research*, 3(7), 749-752.
- Sherlock, J and O'Connor, N. (2015). Research into the Impact of Technology in the Events Industry. *International Hospitality and Tourism Student Journal* 7 (1) 2015 88-102 https://www.academia.edu/30194863/Research_into_the_Impact_of_Technology_in_the_Events_Industry
- Shonhe, L., Jain, P. and Akakandelwa, A. (2023). Students' experiences with the utilisation of the 4IR technologies in online learning: a case study of institutions of higher learning in Botswana and Zambia. *Regional Journal of Information and Knowledge Management*, 8 (2), 81-100.
- Siamuzwe, F. (2012). An Investigation of Levels of Motivation among Librarians in the Tertiary Institutions of Learning in Zambia. <https://dspace.unza.zm/server/api/core/bitstreams/a7276855-9309-484b-9d81-c390f617a3f1/content>
- Siddiqi, K. A. J. and Jamal, A. Z. (2024). Organizational Culture and Its Effect on Employee Motivation. <https://www.researchgate.net/publication/382520259>
- Signé, L. and Ndung'u, N. (2020) Capturing the Fourth Industrial Revolution—A Regional and National Agenda. *Brookings Foresight Africa*. <https://www.brookings.edu/wp-content/uploads/2020/01/ForesightAfrica2020>
- Silver, H. (2017). Use of Collaborative Spaces in an Academic Library. <https://www.researchgate.net/publication/37160888>
- Simpson, R. (2017). Formalized responsibility modelling for automated socio-technical systems analysis. (Doctoral Thesis). School of Computing Science College of Science and Engineering University of Glasgow. <http://theses.gla.ac.uk/8495/1/2017simpsonphd.pdf>

- Singh, N and Mahajan, P. (2014). Application of RFID Technology in Libraries.
<https://www.researchgate.net/publication/272576139>
- Singh, P. K and Gangopadhyay, S. (2017). Digital Divide in Higher Education: Role of Academic Libraries to Bridge the Gap.
<https://www.researchgate.net/publication/322618568>
- Singh, P.K and Rana, P (2022). Potential of augmented reality in optimization of military libraries services: A review. *DESIDOC Journal of Library & Information Technology*, 42(6), 404-413.
- Singh, P. K. and Gangopadhyay, S. (2017). Digital Divide in Higher Education: Role of Academic Libraries to Bridge the Gap.
<https://www.researchgate.net/publication/322618568>
- Sinha. P. and Brar, K. S. (2022). Application of Internet of Things (IoT) in Libraries.
<https://www.researchgate.net/publication/362544831>
- Slife, B. D. (2016). Using operational definitions in research: A best-practices approach.
<https://www.researchgate.net/publication/311558875>
- Smith, D. L and Wu, W. (2014). Collaborative resource sharing between public and school libraries. <https://www.researchgate.net/publication/280185682>
- Snieder, R., et al. (2010). The art of being a scientist: A guide for graduate students and their mentors. *Cambridge: Cambridge University Press*.
<https://www.researchgate.net/publication/243392231>
- Sonnenwald, D. H. et al. (1999). Collaboration Services in a Participatory Digital Library: An Emerging Design. <https://www.researchgate.net/publication/243425339>
- Sony, M., and Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in Society*, 61(3), DOI: 10.1016/j.techsoc.2020.101248
- Subaveerapandiyan A. (2023). Application of Artificial Intelligence (AI) In Libraries and Its Impact on Library Operations Review.
<https://www.researchgate.net/publication/385284920>
- Subaveerapandiyan A. (2024). Digital Transformation in Libraries: Assessing Metaverse

- Readiness in Nigeria. <https://www.researchgate.net/publication/385916469>
- Subaveerapandiyan, A. (2023). Application of Artificial Intelligence (AI) In Libraries and Its Impact on Library Operations Review. <https://www.researchgate.net/publication/385284920>
- Suber, P. (2012) Open Access. MIT Press, Cambridge, MA. <https://doi.org/10.7551/mitpress/9286.001.0001>
- Sukula, S. K. et al. (2023). Data-Driven Decision Making in Academic Libraries: A Review of Developments and Future Prospects. <https://www.researchgate.net/publication/372894083>
- Suman, A and , Patel, M. (2021). An Introduction to Blockchain Technology and Its Application in Libraries. *Library Philosophy and Practice (e-journal)*. 6630. <https://digitalcommons.unl.edu/libphilprac/6630>
- Suman, A. K. (2021). An Introduction to Blockchain Technology and Its Application in Libraries. <https://www.researchgate.net/publication/357393092>
- Suman, A. K. and Patel, M. (2021). An Introduction to Blockchain Technology and Its Application in Libraries. <https://www.researchgate.net/publication/358237117>
- Surindra, D. (2024). Challenges of implementing Industry 4.0 in developed and developing countries: A comparative review. <https://www.researchgate.net/publication/387542186>
- Swain, D. K. (2014). Cloud computing and its application in library management. <https://www.researchgate.net/publication/298721580>
- Swain, D. K. (2014). Cloud computing and its application in library management. <https://www.researchgate.net/publication/298721580>
- Swaminathan, K. S.M. (2021). Cloud Computing in Academic Libraries -An Overview. *Indian Journal of Library and Information Science*. <https://www.researchgate.net/publication/348898826>
- Tait, E. et al. (2016). Libraries for the future: The role of IT utilities in the transformation of academic libraries. *Palgrave communications*, 2(5). <https://doi.org/10.1057/palcomms.2016.70>

- Tang, Y and Shichao Chen, S. (2020) A Blockchain-based Educational Digital Assets Management System. <https://www.researchgate.net/publication/351897271>
- Tantawi, K. et al. (2019). Advances in Industrial Robotics: From Industry 3.0 Automation to Industry 4.0 Collaboration. <https://www.researchgate.net/publication/339760341>
- Tarsik, N. F. et al (2024). Readiness of Academic Libraries for Blockchain Technology: A Conceptual Exploration. <https://www.puo.edu.my/webportal/wp-content/uploads/2024/06/03.-READINESS-OF-ACADEMIC-LIBRARIES.pdf>
- Tawalbeh, L. et al. (2020). IoT Privacy and Security: Challenges and Solutions. <https://doi.org/10.3390/app10124102>
- Tella, A. (2020). Repackaging LIS professionals and libraries for the fourth industrial revolution. *Library Hi Tech News*, 37 (8), 1-6. <https://doi.org/10.1108/LHTN-02-2020-0016>
- Tella, A. (2020). Robots are coming to the libraries: are librarians ready to accommodate them? *Library Hi Tech News*, 37 (8), 13-17. <https://doi.org/10.1108/LHTN-05-2020>
- Tella, A. and Ajani, Y. A. (2022). Robots and public libraries. <https://www.researchgate.net/publication/361941297>
- Tella, A. et al. (2022). The future of libraries in Nigeria during the Fourth Industrial Revolution. *Libraries and the Academy*, 22 (3), 547–558.
- Teo, T. (2011) Factors Influencing Teachers' Intention to Use Technology: Model Development and Test. *Computers & Education*, 57, 2432-2440. <http://dx.doi.org/10.1016/j.tele.2012.01.006>
- Thangiah, R. and Leo, M. J. (2014). Digital Transformation of Academic Libraries. <https://www.researchgate.net/publication/379543120>
- Thiruppathi, K. and Pub, I. (2024). Librarian's Role in the Digital Age: Reimagining the Profession in the Era of Information Abundance. <https://www.researchgate.net/publication/377817735>
- Thompson, L. F., and Mayhorn, C. B. (2012). Aging workers and technology. In J. W. Hedge & W. C. Borman (Eds.), *The Oxford handbook of work and aging* (pp. 341–361). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780195385052.013.0113>

- Tomac, N., Radonja, R and Bonato, J. (2019). Analysis of Henry Ford's contribution to production and management. <https://www.researchgate.net/publication/334136408>
- Tripathi, A and Tripathi, A. (2024). The Impact of Artificial Intelligence on Library Services and Information Management. *Library Philosophy and Practice (e-journal)*. 8148. <https://digitalcommons.unl.edu/libphilprac/8148>
- Tshabalala, N and Dube, L. (2024). Emerging technologies and skills to improve service delivery in digital libraries. <https://sajlis.journals.ac.za/pub/article/view/2393/1671>
- Ubogu, J. O., and Okiy, R.B. (2011). Sources of funds in academic libraries in Delta State, Nigeria. *Library Philosophy and Practice*, 676. <https://digitalcommons.unl.edu/libphilprac/676>
- Udochukwu, D. P and Oraekwe, C. A. (2021). The Fourth Industrial Revolution and the Libraries. <https://www.researchgate.net/publication/348337454>
- Ullah, A. (2023). Challenges in delivering modern library services in the 21st century. <https://www.researchgate.net/publication/375420061>
- Unegbu, V. E. (2020). The Role of Motivation in Librarians' Job Performance in Public University Libraries. <https://doi.org/10.15640/jmise.v7n1a1>
- UNESCO. (2003). Digital preservation and access: Guidelines for libraries and archives. *UNESCO Publications*.
- UNESCO. (2021). United Nations Sustainable Development Goal 4: Ensure inclusive and equitable quality education. Retrieved from <https://www.unesco.org>.
- United Nations (2014). United Nations e-government global survey. <http://unpan3.un.org/egovkb/en-us/Reports/UNE-Government-Survey-2014>
- Usman, M and Adnan Ullah, A. (2024). Blockchain Technology Implementation in Libraries: An Overview of Potential Benefits and Challenges. <https://www.researchgate.net/publication/384812602>
- Valdez, A. C. et al. (2016). Preparing production systems for the internet of Things - The potential of socio-technical approaches in dealing with complexity. Proceedings of the 6th International Conference on Competitive Manufacturing 2016 (COMA '16), (pp.483-487). <https://www.academia.edu/21052601>

- Venkatesan, S. (2014). Best Practice of Preservation Management in Library Digital Collection Materials: Over View. <https://www.researchgate.net/publication/278021149>
- Venkatesh, V., and Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, 39(2), 273-315. <https://www.researchgate.net/publication/247644487>
- Venkatesh, V., et al. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, 27(3), 425-478. <https://www.researchgate.net/publication/247644487>
- Venkatesh, V., Thong, J. Y. L., and Xu, X. (2012). Consumer acceptance and use of information technology. *MIS Quarterly*, 36(1), 157-178. https://www.researchgate.net/publication/220260065_
- Venugopal, K and Somanadh, K. V. (2024). Smart Library Systems: Integrating IOT for Enhanced User Experience. <https://www.researchgate.net/publication/383062233>
- Vijayakumar, K., & Sheshadri, N. (2019). Applications of Artificial Intelligence in Academic Libraries. *International Journal of Computer Sciences and Engineering*, 7(16),137-140 DOI: <https://doi.org/10.26438/ijcse/v7si16.136140>
- Vos, J. F. J., and Rupert, J. (2018). Change agent's contribution to recipients' resistance to change. <https://doi.org/10.1016/j.emj.2017.11.004>
- Vrana, R. (2011). Digital repositories and the future of preservation and use of scientific knowledge. <https://www.researchgate.net/publication/289806868>
- Vysakh, C., & Rajendra, B. (2020a). Application of Artificially Intelligent Robot in Libraries. ICRLIT – 2019: E-Proceedings Reshaping of Librarianship, Innovations and Transformation. <https://www.academia.edu/75507415>
- Wang, W. et al. (2017). Meeting the Needs of Post-Millennial: Lending Hot Devices Enables Innovative Library Services. *Ifla Journal*, 44(4), 253-349 https://www.ifla.org/files/assets/hq/publications/ifla-journal/ifla-journal-44-4_2018.pdf
- Warren, B. (2020). Developing a practical approach to change. *College & research libraries*,
- Weiner, S. G. (2003). Resistance to Change in Libraries: Application of Communication

- Theories. <https://www.researchgate.net/publication/211395943>
- Whitlatch, J., and Searing, S.E. (2014). Guide to reference essential general reference and library science sources. Anita Ponne/Shutterstock.
- Wilson, M. et al. (2010). Assessment and Teaching of 21st Century Skills: Perspectives on Methodological Issues Learning and Technology World Forum 2010. *White Paper presented at the Learning and Technology World Forum 2010, London. Online Learning 20.2 Full- Issue pdf.pdf (ed.gov)*
- Winkler, D., and Kiszl, P. (2021). Views of Academic Library Directors on Artificial Intelligence: A Representative Survey in Hungary. <https://www.researchgate.net/publication/351620473>
- Xia, et al. (2012). Is global competitive index a good standard to measure economic growth? A suggestion for improvement. *International Journal of Services and Standards*, 8(1),
- Xing, B., and Marwala, T. (2017). Implications of the Fourth Industrial Age on Higher Education. <https://www.researchgate.net/publication/315682580>
- Xu, M. et al. (2018). The Fourth Industrial Revolution: Opportunities and challenges. *International Journal of Financial Research*, 9(2), 90-95
<http://dio.org/10.5430/ijfr.v9n2p90>
- Yang, C. (2019). The Fourth Industrial Revolution, Aging Workers, Older Learners, and Lifelong Learning. Adult Education Research Conference. <https://newprairiepress.org/aerc/2019/papers/35>
- Yao, X., and Li, W. (2015). Intelligent robots for improving library services. *Journal of Library Robotics*, 11(1), 8–17.
- Yaya, J. A. (2023). Effect of Library Management Software on the Growth and Development of Library Services Growth and Development of Library Services. <https://digitalcommons.unl.edu/libphilprac>
- Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publications. https://iwansuharyanto.wordpress.com/wp-content/uploads/2013/04/robert_k-_yin_case_study_research_design_and_mebookfi-org.pdf
- Yu, K. et al. (2019). The application of artificial intelligence in smart library. *International*

Conference of Organizational Innovation. <https://download.atlantis-press.com/article/125919402.pdf>

Yudipratomo, O and City and Irwansyah. (2020). Communication Technology

Advancements in Industrial Revolution.

<https://www.researchgate.net/publication/348113662>

Yusuf, B., Walters, L.M., and Sailin, S.N. (2020). Restructuring Educational Institutions for

Growth in the Fourth Industrial Revolution (4IR): A Systematic Review. *iJET*, 15 (3).

<https://doi.org/10.3991/ijet.v15i03.1184>

Yuvaraj, M. (2016). Determining factors for the adoption of cloud computing in developing

countries: A case study of Indian academic libraries.

<https://www.researchgate.net/publication/309258782>

Zarnitz, M. (2019). The Strategic Collaboration of Libraries in Digital Preservation.

https://www.researchgate.net/publication/336311828_

Zerouani, H. (2023). Chatbots Technology and its Challenges: An Overview.

<https://www.researchgate.net/publication/371464104>

Zervoudi, E.K. (2020). Fourth industrial revolution: Opportunities, challenges, and proposed

policies. <https://www.intechopen.com/chapters/70877>

Zhang, L. (2019). Blockchain: The New Technology and its Applications for Libraries.

Journal of Electronic Resources Librarianship, 31, 4, 278-280.

<http://doi.org/10.1080/1941126X.2019.1670488>

Zhang, Y. et al. (2015). Convergence of digital humanities and digital libraries.

<https://www.researchgate.net/publication/277940906>

Zhou, K. et al. (2015). *Industry 4.0: Towards future industrial opportunities and challenges*.

In *Fuzzy Systems and Knowledge Discovery (FSKD)*, 2015 12th International

Conference on (pp. 2147-2152). IEEE. <https://ieeexplore.ieee.org/document/7382284>

Zhou, Q. (2018). Academic Libraries in Research Data Management Service: Perceptions and

Practices. <https://www.scirp.org/journal/paperinformation?paperid=85393>

Appendix I: Consent Letter

Dear Respondent

I am a student at The University of Zambia pursuing a Doctorate of Philosophy (PhD) in Library and Information Science. As part of the requirements for completing the programme, I am conducting a research project titled: "*The Effect of the Fourth Industrial Revolution on Library Services: A Case Study of Academic Libraries in Lusaka Province.*"

I kindly request your participation in this research by filling out a short questionnaire. Please indicate your responses by placing a tick (✓) in the appropriate boxes.

The information collected will be used solely for academic purposes. There are no risks involved in participating in this study, and your confidentiality will be maintained. The results collected may be used to enhance the adoption of Fourth Industrial Revolution technologies in library services.

Authorization:

I have read and understood the nature of this study. I am aware that by agreeing to participate, I have not waived any legal or human rights. I understand that I may contact the researcher, Kadeyo Mutale Kuyela, at any time via phone (0971946568) or email (kadeyo94@gmail.com).

By agreeing to participate, I acknowledge that I may refuse or withdraw from the study at any time without prejudice. I also grant permission to the researcher to publish data from this study, provided that my identity remains anonymous.

Participant Signature

Date

Researcher Signature

Date

Appendix II: Questionnaire for Respondents

Dear Respondents

Introduction

My name is Kadeyo Mutale Kuyela, and I am currently pursuing a Doctorate of Philosophy in Library and Information Science (PhD) at the University of Zambia. I am researching the effect of the Fourth Industrial Revolution on library services. A case study on academic libraries in Lusaka Province. You have been chosen to participate in this study by completing this questionnaire. I would be grateful if you could try to answer all of the questions to the best of your ability. You must also be assured that the information gathered through this questionnaire will be kept strictly confidential and used only for academic purposes. Thank you.

If any queries or difficulties are noticed, please do not hesitate to forward them to my email address; kadeyo94@gmail.com, or cellphone number(s); **0971946568 or 0968411711**

Your collaboration in this regard will be highly treasured.

Yours faithfully,

Kadeyo Mutale Kuyela

Section A: Background Information of the Respondent

1. What is your gender?
 - a) Male
 - b) Female
2. Age of the respondent
 - a) 20 – 24 years
 - b) 25 – 29 years
 - c) 30 – 34 years
 - d) 35 –39 years
 - e) 40 years and above
3. What is your current job title?
 - a) Chief librarian
 - b) Deputy librarian
 - c) Librarian
 - d) Assistant librarian
 - e) Senior library assistant
 - f) Library assistant
4. What is your highest level of education?
 - a) Certificate
 - b) Diploma
 - c) Bachelor's degree
 - d) Master's degree
 - e) Doctoral degree
5. How long have you been working in the Library?
 - a) Less than 1 year
 - b) 1-4 years
 - c) 5-8 years
 - d) 9-year and above
6. Which of the following sections of the library do you work in?
 - a) Reference services
 - b) Electronic resources
 - c) IT support unit
 - d) Cataloguing
 - e) Circulation
 - f) Acquisition

- g) Institutional repository
- h) Other. Please stated

7. How would you rate the current level of technological adoption in your library?

- a) Very High
- b) High
- c) Moderate
- d) Low

Section B: To examine the extent to which academic libraries have adopted the Fourth Industrial Revolution technologies within their library services.

8. How did you get to know about the Fourth Industrial Revolution (4IR)?

- a) During information literacy training programme
- b) Research work
- c) Internet
- d) Social media platforms
- e) University website
- f) Staff meeting
- g) Conference / Seminar
- h) Other. Please stated

9. What new (LIB4.0) technologies and applications are available in your library due to the 4IR?

- a) Artificial intelligence
- b) Big data tools (e.g Batch analysis tools, interactive tools, stream analysis tools)
- c) Virtual reality
- d) Clouding computing
- e) Blockchain technology
- f) Internet of Things (IoT)
- g) Digital library repositories (Dspace, Fedora commons)
Biometric security sensor for check-in and check out
- h) Library social media platform
- i) Reference management tools (e.g. Mendeley, endnote, Sotero)
- j) 3D modelling software
- k) Chatbot
- l) Circulation module

10. To what extent has your library implemented artificial intelligence (AI) for cataloguing and indexing?

- a) Fully implemented
- b) Partially implemented

- c) Planning to implement
- d) Not considered

11. How often does your library use machine learning algorithms for personalised recommendation services?

- a) Frequently
- b) Occasionally
- c) Rarely
- d) Never

12. What is the current status of robotic automation for routine tasks (e.g., book sorting, shelving) in your library?

- a) Fully operational
- b) Pilot phase
- c) Planning stage
- d) Not considered

13. To what extent are virtual reality (VR) and augmented reality (AR) technologies used in your library for educational purposes?

- a) Extensively used
- b) Moderately used
- c) Minimally used
- d) Not used

14. How integrated are Internet of Things (IoT) devices (e.g., smart sensors, RFID) in managing library resources?

- a) Fully integrated
- b) Partially integrated
- c) In planning stage
- d) Not integrated

15. What level of adoption does your library have for blockchain technology in digital rights management?

- a) Fully adopted
- b) Partially adopted
- c) Exploring possibilities
- d) Not adopted

16. How frequently does your library use data analytics and big data to enhance decision-making processes?

- a) Very frequently
- b) Occasionally
- c) Rarely
- d) Never

17. To what extent are cloud computing services used for storing and accessing library data?

- a) Extensively used
- b) Moderately used
- c) Minimally used
- d) Not used

18. How effective has the adoption of chatbots been in providing user support and reference services?

- a) Very effective
- b) Somewhat effective
- c) Ineffective
- d) Not adopted

19. What is the current stage of implementing 3D printing services in your library for educational and research purposes?

- a) Fully implemented
- b) Partially implemented
- c) Planning to implement
- d) Not considered

20. What are the reasons for using Lib 4.0 technologies and applications in your library?

- a) To make library services easier to use and access
- b) To inspire and inform patrons to patronise library services
- c) To help patrons learn new skills
- d) To stay relevant in providing library services
- e) To attract new and maintain existing customers

Section C: To investigate how the Fourth Industrial Revolution has influenced information access and retrieval methods

21. What technological advancement is most commonly used in academic libraries for information retrieval due to the Fourth Industrial Revolution?

- a) Printed catalogues
- b) Barcode scanning
- c) Artificial Intelligence (AI)
- d) Fax machines

22. How has the Fourth Industrial Revolution impacted the role of librarians in academic libraries?

- a) Increased manual cataloguing tasks
- b) Reduced the need for librarians
- c) Enhanced roles in managing digital resources
- d) No significant impact

23. What is the primary benefit of AI in academic library information retrieval?

- a) Faster processing of physical books
- b) Improved accuracy in search results
- c) Lower costs of physical infrastructure
- d) Increased physical book circulation

24. Which of the following best describes the effect of the Fourth Industrial Revolution on user access to academic library resources?

- a) Decreased online access
- b) Increased physical visits to libraries
- c) Enhanced remote access to digital collections
- d) Reduced availability of e-books

25. What type of information retrieval method has become more prevalent in academic libraries due to advancements in the Fourth Industrial Revolution?

- a) Manual card catalogues
- b) Online databases with advanced search algorithms
- c) Paper-based indexing
- d) Book-by-book physical searches

26. How have academic libraries enhanced user experience with the help of Fourth Industrial Revolution technologies?

- a) By maintaining more printed journals
- b) By introducing automated chatbots for assistance
- c) By limiting access to digital resources
- d) By reducing the number of library staff

27. Which of the following is a direct result of the Fourth Industrial Revolution in academic library resource management?

- a) More reliance on microfilm archives
- b) Development of digital repositories
- c) Increased use of typewriters for documentation
- d) Greater emphasis on physical book preservation

Section D: To assess the skills and training requirements of library staff in response to the Fourth Industrial Revolution

28. How confident are you in using digital library management systems?

- a) Very confident
- b) Confident
- c) Somewhat confident
- d) Not confident

29. How often do you engage in professional development activities related to emerging technologies?

- a) Frequently
- b) Occasionally
- c) Rarely
- d) Never

33. How familiar are you with data analytics tools for library management?

- a) Very familiar
- b) Familiar
- c) Somewhat familiar
- d) Not familiar

34. How would you rate your ability to teach patrons how to use new digital resources?

- a) Excellent
- b) Good

- c) Fair
- d) Poor

35. What is your level of comfort with using AI-based library systems?

- a) Very comfortable
- b) Comfortable
- c) Somewhat comfortable
- d) Not comfortable

36. How well do you understand the concept of digital literacy and its importance?

- a) Very well
- b) Well
- c) Somewhat
- d) Not at all

37. How often do you participate in training programs related to Fourth Industrial Revolution technologies?

- a) Very often
- b) Often
- c) Sometimes
- d) Rarely

38. How proficient are you in using cloud-based library services and integrating virtual reality (VR) or augmented reality (AR) into library services?

- a) Very proficient
- b) Proficient
- c) Somewhat proficient
- d) Not proficient

39. What is your experience level with integrating virtual reality (VR) or augmented reality (AR) into library services?

- a) Extensive experience
- b) Moderate experience
- c) Limited experience
- d) No experience

40. How important do you believe ongoing training in emerging technologies is for library staff?

- a) Extremely important
- b) Very important
- c) Somewhat important
- d) Not important at all

41. What type of training is most beneficial for library staff in a technologically evolving environment?

- a) Data management and analytics
- b) Artificial intelligence and machine learning
- c) Digital literacy and technology proficiency
- d) Digital content curation and preservation

42. How do you rate the current skill level of your staff in handling Fourth Industrial Revolution technologies?

- a) Highly skilled
- b) Moderately skilled
- c) Slightly skilled
- d) Not skilled at all

43. On a scale of 1 to 5, where **1=strongly disagree, 2=disagree, 3= neutral, 4=agree, and 5= strongly agree**. How would you rate the perceived usefulness, perceived ease-of-use, attitude towards using and behavioural intention to use on the Fourth Industrial Revolution (4IR) technologies such as Artificial Intelligence (AI), Internet of Things (IoT), Blockchain technology, Big data analytics, Augmented Reality (AR) and Virtual Reality (VR), Cloud computing and Automation.

Constructs	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Perceived Usefulness (PU)					
Using the Artificial Intelligence (AI) in the library improves my performance in my job.					

Using Internet of Things (IoT) in my job increases my productivity.					
Perceived Ease-of-Use (PEOU)					
I find the Artificial Intelligence driven cataloguing systems to be easy to use					
My interaction with Big data analytics is clear and understandable					
Attitude towards Using					
Assuming I have access to Augmented Reality (AR) and Virtual Reality (VR), I intend to use it.					
I have a positive attitude towards using cloud computing					
Behavioural intention to Use					
I will recommend automation in academic libraries to my peers.					
I intend to continue using the Blockchain technology in future job as a librarian.					

44. To what extent do you agree with the following statements about integrating Fourth Industrial Revolution technologies in library service?

Statements	Strongly agree	Agree	Disagree	Strongly disagree
Using AI in the library improves my performance.				
AI-driven cataloguing systems are easy to use.				
I have a positive attitude towards cloud computing.				
I will recommend automation in libraries.				
I intend to use blockchain in future library jobs.				

Section E: To explore the challenges faced by academic libraries in adopting the Fourth Industrial Revolution technologies in their library services

45. What is the primary challenge your library faces in integrating Fourth Industrial Revolution technologies?

- a) Lack of funding
- b) Insufficient training for staff
- c) Resistance to change among staff
- d) Inadequate technical infrastructure
- e) Limited understanding of technologies
- f) Fear of losing my job as new technology emerges
- g) Lack of ICT skillset to utilise Library 4.0 technologies

THE END

Appendix III: Ethical Clearance Approval Letter



THE UNIVERSITY OF ZAMBIA DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

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APPROVAL OF STUDY

IORG No. 0005376
HSSREC IRB No. 00006464
REF NO. HSSREC-2024-AUG-029

27th September, 2024

Mr Kadeyo Mutale Kuyela
The University of Zambia
P.O. Box 32379
LUSAKA

Dear Mr Kuyela

RE: "AN ASSESSMENT OF THE EFFECT OF THE FOURTH INDUSTRIAL REVOLUTION ON LIBRARY SERVICES: A CASE STUDY OF ACADEMIC LIBRARIES IN LUSAKA PROVINCE"

Reference is made to your submission of the protocol captioned above. The HSSREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

REVIEW TYPE	ORDINARY REVIEW	APPROVAL NO. HSSREC:- 2024-AUG-029
Approval and Expiry Date	Approval Date: 27 th September, 2024	Expiry Date: 26 th September, 2025
Protocol Version and Date	Version - Nil.	26 th September, 2025
Information Sheet, Consent Forms and Dates	<input type="checkbox"/> English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	
Number of Participants Approved for Study		

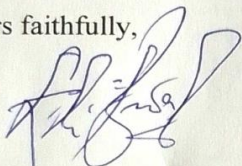
Towards Improving Service and Excellence in High Education Beyond Fifty Years

- A reprint of this letter shall be done at a fee.
- All protocol modifications must be approved by HSSREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by HSSREC before they can be implemented.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of HSSREC, we would like to wish you all the success as you carry out your study.

Yours faithfully,



DR. ELIJAH M. BWALYA
ACTING CHAIRPERSON
THE UNIVERSITY OF ZAMBIA HUMANITIES AND
SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE - IRB

CC: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies

