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**Academic Libraries in the Context of Forth Industrial Revolution (4IR): Opportunities and Challenges**

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**Abstract**

*This paper examined academic libraries in the context of Forth Industrial Revolution (4IR): opportunities and challenges. The 4IR is considered to be the outcome of the convergence of a number of technologies in industrial operations. This includes the proliferation of robotics, artificial intelligence, cloud computing and big data with the human body through wearable technologies. The 4IR brought about advance changes in the academic libraries and this led to the emergence of other issues such as library automation, embedded librarianship, open science and the use of social media platforms. Adoption of 4IR in academic libraries resulted to several phases of development and these include the emergence or use of Machine Readable Cataloguing (MARC) and Online Public Access Catalogue (OPAC), audio visual media systems and web-based indexing. Some of the opportunities 4IR avail academic libraries is that, library users are now able to afford and access the digital world by the advances in technology regardless of time and location. Academic libraries are now offering both on and off campus access to information resources and users enjoy 24/7 services. However, 4IR has posed some challenges in information safety and security while data is accessible everywhere. Ensuring data quality and transparency is another obstacle. Also, as recommendation, modern academic library requires librarians to have sufficient and eligible qualities and skills beyond the usual library skills. In addition, there should be a special training and acquisition of skills on the operation and maintenance of 4IR in academic libraries in Nigeria.*

**Keywords:** Industrial Revolution, Forth Industrial Revolution (4IR), Academic Library

**Introduction**

The Fourth Industrial Revolution (4IR) also known as Industry 4.0 is the current and developing environment where modern technologies such as the Internet of Things (IoT), robotics, Artificial Intelligence (AI) and virtual reality are changing how libraries operate. The oddments of information reported by the media give the impression that robot, AI, cloud-based computing, big data and a combination of other technologies are gradually converging and merging to create a new reality which has the potential for revolutionising all aspects of life. The 4IR is considered to be the outcome of the convergence of a number of technologies in industrial operations such as the proliferation of robotics, AI, cloud computing, big data, linked data, 3D printing, biotechnology and the integration of technology with the human body through wearable technologies (Hussain, 2019). These technologies are underpinned by access to datasets.

Globally, the 4IR era has greatly affected the way library and information centres conduct their daily activities in ensuring that the dynamic and diverse needs of users are met. More importantly, focus has been on innovation forcing the libraries to re-examine the way they conduct their services leading to transformation of production, management and governance

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in libraries. The Industry 4.0 era is calling for a librarian who has an in-depth knowledge of a specific field with sufficient knowledge of other fields including the ability to use the panoply of digital technologies in various areas. Chisita & Chibanda (2019) highlighted that digital technologies were stimulating revolutionary changes among libraries by changing how work is done or accomplished in academic libraries.

Therefore, there is need to develop a library workforce that is not threatened by these new technologies through continuous professional development. Ahmat & Hanipah (2018) pointed out four strategic actions that should be taken by academic libraries to control the disruptive changes brought about by the 4IR. These are reshaping organisational behaviour, redesigning service model, restructuring service process workflow and remaking job descriptions and roles. There are various types of libraries which include academic, school, public and special, and all these libraries are expected to move along with these changes.

Hirschi (2018) noted that the gig or sharing economy would create new opportunities through crowd work and work on demand via applications (De Stefano, 2016). In crowd work, individuals complete a series of tasks online (for example, reviewing documents, annotating photos and entering data) for an infinite number of organisations worldwide that are facilitated by a platform. This economy will facilitate the growth of independent information practice in the form of information consultants, brokers, vendors and mediators. De Mauro, Greco & Grimaldi (2016) stressed how the 4IR would enhance the value of librarians and their role in big data by creating value with regard to bibliometric, data sharing and data curation. Thelwall (2008) argued that the emergence of the networked milieu has resulted in bibliometric evolving into closely related virgin subfields such as webometrics, infometrics and altmetrics, analysing statistical patterns between digital documents and sets of data. Big data is the information asset characterised by such high volume, velocity and variety to require specific technology and analytical methods for its transformation into value (De Mauro, Greco & Grimaldi, 2016).

**Literature Review**

**Historical Development of the 4th Industrial Revolution**

The industrial revolution started during the Eighteenth to Nineteenth centuries in Europe and America in the iron and textile industries when the steam engine was invented. The second industrial revolution took place from 1870 to 1940 prior to World War II (1939–1945) when steel, oil, electricity and electric power were used for mass production, telephone, light bulbs, phonograph and internal combustion engine were developed. Frederick (2016) noted that the phrase 'industrial revolution' is a buzzword that many readers undoubtedly encountered in their school history lessons and likely associated with a time-period lasting from the late Eighteenth century to the mid Nineteenth century where small home based industries gradually succumbed to larger scale production in industrial shops. The industrial revolution was set into motion by technological changes in the form of invention of machines which could manufacture products faster and more efficiently than the home-based craftsperson. The third industrial revolution is regarded as the digital revolution where there was advancement in technology from analogue electronic and mechanical devices to the digital technology from 1980. There was the advent of personal computers, internet and Information and Communication Technology (ICT). The 4IR was coined by Klaus Schwab, a German engineer and economist who is best known as the founder and executive chairman of the World Economic Forum (Schwab, 2019). He pointed out that the 4IR will affect the essence

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of human experience (Lewin, Smith, Morris & Craig, 2019).

Academic libraries have encountered three phases of development within these industrial revolutions and these include the emergence of automation systems leading to the use of Machine Readable Cataloguing (MARC), Online Public Access Catalogue (OPAC), audio visual media systems and web-based indexing. The development of CD-ROMs, full-text databases, internet and web and the advancement of new technology that was used to accomplish complex tasks (Ahmat & Hanipah, 2018). This led to the development of maker spaces in academic libraries where there are collaborative work spaces for making, learning, exploring and sharing using high-technology tools and applications (Smith, 2019). Some librarians are now responsible for teaching robotics, coding and programming skills to library users. The generation of industrial revolution is noted by Sentryo (2017) as thus:

**First Industrial Revolution – 1765**

Following a slow period of proto-industrialisation, this first revolution spans from the end of the 18th century to the beginning of the 19th century. It witnessed the emergence of mechanisation, a process that replaced agriculture with industry as the foundations of the economic structure of society. Mass extraction of coal along with the invention of the steam engine created a new type of energy that thrusted forward all processes thanks to the development of railroads and the acceleration of economic, human and material exchanges. Other major inventions such as forging and new know-how in metal shaping gradually drew up the blueprints for the first factories and cities as we know them today.

**Second Industrial Revolution – 1870**

Nearly a century later at the end of the 19th century, new technological advancements initiated the emergence of a new source of energy: electricity, gas and oil. As a result, the development of the combustion engine set out to use these new resources to their full potential. Furthermore, the steel industry began to develop and grow alongside the exponential demands for steel. Chemical synthesis also developed to bring us synthetic fabric, dyes and fertilizer. Methods of communication were also revolutionised with the invention of the telegraph and the telephone and transportation methods with the emergence of the automobile and the plane at the beginning of the 20th century. All these inventions were made possible by centralising research and capital structured around an economic and industrial model based on new “large factories” and the organisational models of production.

**Third Industrial Revolution – 1969**

Nearly a century later, in the second half of the 20th century, a third industrial revolution appeared with the emergence of a new type of energy whose potential surpassed its predecessors. This revolution witnessed the rise of electronics with the transistor and microprocessor, also, the rise of telecommunications and computers. This new technology led to the production of miniaturised material which would open doors, most notably is space research and biotechnology. For industry, this revolution gave rise to the era of high-level automation in production link to two major inventions; automatons Programmable Logic Controllers (PLCs) and robots.

**Fourth Industrial Revolution (Industry 4.0)**

The fourth revolution is unfolding before our eyes. Its genesis is situated at the dawn of the third millennium with the emergence of the internet. This is the first industrial revolution rooted in a new technological phenomenon digitalisation rather than in the emergence of a new type of energy. This digitalisation enables us to build a new virtual world from which we

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can steer the physical world. The industry of today and tomorrow aim to connect all production means to enable their interaction in real time. Factories 4.0 make communication among the different players and connected objects in production line possible due to technologies such as cloud, big data analytics and the industrial internet of things. The applications for the industrial sector are already enormous: predictive maintenance, improved decision-making in real time, anticipating inventory based on production, improved coordination among jobs, etc. Day after day, all these improvements are gradually optimising production tools and revealing endless possibilities for the future of industry 4.0, the crossroads for an interconnected global system. However, this fourth industrial revolution could be the first to deviate from the energy-greed trend in terms of non-renewable resources because we have been integrating more and more possibilities to power our production processes with alternative resources. Tomorrow, factories 4.0 will be embedded in smart cities and powered by wind, sun and geothermal energy.

**Industry 4.0 Tools and Applications in Academic Libraries**

The 4IR is driven by specific types of technology which are big data, AI, robotics, virtual and augmented reality, advanced security systems, and the IoT (Norta, Hawthorne & Engel, 2018). Romanovs, Pichkalov, Sabanovic, & Skirelis (2019) added that there are growing technologies in the 4IR which include drones, 3D printing, AI, nanotechnology, robotics, among others. This has led to the increasing digitisation of products and services which is termed Internet of Things (IoT). These tools and applications have the potential to boost productivity in academic libraries and can reduce costs as well as improve the quality of products and services.

**Information Communication Infrastructure**

Information communication infrastructure and emerging technologies such as cloud computing, IoT, that is the development of smart products, the internet of services and internet of energy topped the list in the 4IR (Lom, Pribyl & Svitek, 2016). Digital connectivity in the industry 4.0 era is provided by telecommunication technologies such as broadband to ensure that there is digital connectivity to enhance communication and collaboration as stated by the European Commission (2015). Academic libraries can take advantage of the use of 5G technologies, big data, IoT and AI to increase efficiency and to make evidence-based decisions since data analytics can be used to gain more insights in understanding customer preferences, changing market conditions and to enhance efficiency in library services (Golub & Hansson, 2017). High Processing Computer (HPC) is turning out to be a major source of hope for future applications development that require greater amounts of computing resources in various modern science domains such as bioengineering, nanotechnology, the 4IR and energy where HPC capabilities are mandatory in order to run simulations and perform visualisation tasks (Sentryo, 2022).

**Education and Training**

There is an increased demand for skilled labour in the 4IR. Librarians should be skilled, innovative and technological savvy (Manda & Backhouse, 2017; Xing & Marwala, 2017). They noted that the 4IR revolution will result in new forms of universities that will conduct teaching, research, and service in a dissimilar manner. Furthermore, Xing & Marwala (2017) foresaw the novel university characterised by interdisciplinarity, have virtualised classrooms, laboratories, libraries and teachers. This implies that librarians should develop their skills to fit well in the changing work environment. These skills include the use of

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information and communication technologies, communication skills, marketing skills, public relations skills and research skills. Academic libraries should also prepare and anticipate these future skills requirements so as to develop proper training programmes for the librarians and review job descriptions in line with these changes.

**Innovation**

Due to the advent of technology, innovation is a key in the 4IR leading to the need for investment in research and development (Mckinsey Global Institute, 2015). These innovations would assist in addressing developmental challenges. This calls for innovative policy and legislative reforms by academic libraries, institutions and the government to support the digital transformations. Zhou, Liun & Zhou (2015) reiterated the challenges that are brought about by the 4IR which include trade restrictions, data security, liability issues and personal data privacy and these can be dealt with by strict regulations in the form of standards, legislation and policies. The policies would address the issues of skills, training, infrastructure, funding and regulation among others.

**Responsive and Context-specific Strategies**

In dealing with the Industry 4.0, there is need to have strategies that can be utilised by libraries to be efficient and effective. There is need for clear strategies with guidelines on how libraries should respond to the demands and challenges of the digital environment. However, in the developing world, libraries mostly fail to have strategies that respond to the local context. This is stated by Majdalawi, Almarabeh, Mohammad & Quteshate (2015) who pointed out that the major challenge in developing countries is not the absence of strategies but the available strategies do not suit the local settings. Manda & Backhouse (2016) added that developing countries fail to adapt to the best practices leading to the implementation of poor strategies.

**Changes Brought by the 4th Industrial Revolution in Academic Library**

The 4th Industrial Revolution (4IR) brought about a number of changes in the academic libraries and the major change agents are automation and artificial intellegence. This led to the emergence of other issues such as diverse users, library automation, embedded librarianship, open science, the use of social media platforms and the changing roles of librarians. Some librarians feel threatened by the revolution and they believe that some certain groups of employees are getting redundant and will be replaced with new workers with the required skills or with machines. The librarians should be able to answer the information needs of diverse users such as the millennial generation, generation X, Y and Z, and users with special needs. Academic libraries are now promoting digital literacy to ensure that the users are able to access and use the information using various technologies. Most librarians' jobs require digital skills and the use of technology is now a basic requirement. During the digital literacy training sessions, librarians would be unpacking issues such as how to deal with the information overload and imparting skills on how to conduct sound research as well as dealing with fake news on the internet. There are some libraries in the United State of America that have adopted Industry 4.0 tools and applications in their day-today activities. There is an advanced robotic conveyer system that transports books from Bryant Park off-site storage area to New York public library underground (Smith, 2019). Some academic libraries are collecting data using social media tools, drones, cameras and other Industry 4.0 devices to analyse and use it intelligently. The university of Pretoria, South Africa employed Libby, a client service robot in May 2019 as a way of evolving in line with

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the 4IR. According to the University of Pretoria (2019), the robot is responsible for providing guidance, conduct surveys, display marketing videos, and answering queries.

**Opportunities of Academic Libraries in the 4IR Era**

The 4IR brought about many changes which affect the way library services and products are offered. This calls for the need to continuously develop the knowledge and skills of librarians so that they stay abreast of the changes and know how they can positively impact the communities that they serve. There are new services in the research, teaching and learning, and these include big data, research data management, and open science such as open data, open access, open educational resources, and open methodology among other things. This shows that librarians are now taking new roles and responsibilities and they are now regarded as researchers and teachers. Librarians now teach information literacy to impart skills on how to access and evaluate information resources. Therefore, it is important that librarians should develop their skills to remain relevant in the 4IR era.

Library users are now able to afford and access the digital world due to the advances in technology regardless of time and location. Academic libraries are now offering both on and off campus access to information resources and users only need an internet connection to enjoy the facilities where they can access the services 24/7. This has greatly increased the use of electronic resources since convenience of accessing library services had been improved. New products and services that increase the efficiency of library services are also being introduced in academic libraries due to the 4IR. These include the use of social media platforms to communicate with users, online reference services, online renewal of print materials and self-services at circulation points. Academic libraries and librarians will have to reinvent and form a new strategy on how they can benefit from the numerous opportunities arising from the 4IR era.

When we look at the future, according to the debates in our teleconference, academic libraries will be trustworthy information brokers. They will do more with new technology, provide universal access to information and scholarly works, whether media or information known or new media, preserving and providing access to information in all formats and providing trusted and effective support for political and social engagement. Libraries will be advocates for and facilitators of the 4IR, where people create their own devices and objects. (Church, Butz, Cassell, Kamar, Swindells, Tallman & Snellenberg, 2017).

Along with the development of web generations, library generations have bloomed from 1.0, 2.0, 3.0 to the current 4.0 with the ability to bring the virtual world and the real world together (Phan, 2018). Library 1.0 refers to the traditional library generation with Online Public Access Catalog (OPAC) and a single bibliographic database. Library 2.0 refers to the application of web 2.0 into library services, which means applying technology that enables interaction, collaboration, and web-based multimedia tools into library services. Library 2.0 provides a variety of services aimed at meeting the needs and expectations of the users, ensuring the availability of information resources and services everywhere at any time without any obstacles. Library 2.0 makes everything easy and encourages collaboration, participation and involvement from the web management department, technical partners and the broader community. The principles of library 2.0 are to be user-centered and to support the seamless interaction between libraries and the users by such tools as wikis, blogs, Really Simple Syndication (RSS), etc.

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Library 3.0 refers to the library system of emerging technological applications such as the semantic web, cloud computing, mobile devices and the system of tools such as affiliate search systems that support the development, organisation and sharing of user-generated content through seamless collaboration among users, professionals, and libraries. Library 4.0 possesses similarities with web 4.0 and incorporates many similar concepts and technologies. Library 4.0 with the base of web 4.0 is an intelligent library that consists of not only available inference and studies but also the automatic analysing system of the current findings. It can be imagined that a merged environment of various platforms, services and contents that allows the librarians, users and machines to symbiotic, read, write, execute and unify. This is also the library of thinking, making decisions and providing library services using reasoning. Web 4.0 owns a lot of advantages that greatly benefit library 4.0 in adopting information technology. In library 4.0, there is almost no limit on resources in each libraries, users, even the disabled, not only use information from their library as members but also be allowable to access the world's huge library. More importantly, when libraries are connected to share resources, there will be no investment in duplicating documents. This greatly contributes to reduce investment costs for libraries and helps to solve financial difficulties (Duong, 2018).

**Challenges of Academic Library in the 4IR Era**

In addition to the opportunities, academic library 4.0 encountered many challenges due to the requirements of the 4IR. Although the library exists in a long tradition, its role seems to be diminished. Besides, the concept of information service is vaguely understood by the majority. It cannot be denied that the industrial revolution 4.0 has made enormous changes in all aspects of life, which means the speed of technological development will be even higher. The fact urges libraries to renovate the operation and the way of service provision, otherwise, they will be lagged behind. That is, they will no longer be able to fulfill their mission of providing information and knowledge effectively.

Data is essentially the lifeblood of the era of the industry revolution 4.0 because of its importance and utilisation. Without any data, a library cannot be upgraded to a library 4.0. Therefore, a library needs to enrich information resources, especially to build databases with metadata capable of meeting the diversified needs of the users. The Industrial Revolution 4.0 has posed more challenges in information safety and security while data is assessable everywhere. This is a big concern for all the libraries in finding a solution to guarantee the information exchanges among the systems. Besides, ensuring data quality and transparency is also an obstacle (Vu, 2018). A modern library requires librarians to have sufficient and eligible qualities, qualifications and skills beyond the usual library skills.

It is commonly known that the industry revolution 4.0 has made it hard to identify the boundary among libraries as they share the same data source and the library linkage system is becoming more and more popular. Therefore, library and information industry needs to build an appropriate and equal mechanism for linking and sharing resources among libraries. The current inconsistent data structure has influenced the data exchanges among libraries around the world, even some software does not recognize the records as the focused cataloging software to process data posted to Worldcat discovery. This requires the libraries to update and follow international standards in storing and preserving the data for long time use of digital data.

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**Conclusion**

This paper reviews the concept of forth industrial revolution and its application to academic libraries. It can be concluded that application of 4IR to academic libraries have brought about a number of changes in the academic libraries and the major change agents are automation and artificial intelligence. The application of 4IR led to the emergence of other issues such as diverse users, library automation, embedded librarianship, open science, the use of social media platforms and the changing role of librarian's service delivery. By this application of 4IR in academic libraries, librarians are now able to answer the information needs of diverse users such as the millennial generation and users with special needs. Academic libraries are now promoting digital literacy to ensure that the users are able to access and use the information using various technologies.

**Recommendations**

Based on the challenges posed to academic libraries by the application of 4IR, the paper made the following recommendations:

1. Academic libraries should create an awareness service to librarians on the existence and application of 4IR to academic libraries.

2. There should be a special training and acquisition of skills on the operation and maintenance of 4IR in academic libraries.

3. There is a need for full automation of academic libraries to enjoy the full services of 4IR in academic libraries.

4. Librarians are encouraged to embrace the adaption of ICT skills to fit in the operation of 4IR in academic libraries.

There is a need for mother institutions and the government to release adequate funds to digitalised academic libraries and acquire the necessary infrastructures needed to enable academic libraries enjoy full services of 4IR.

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