# Keynote Paper

# Realigning Library and Information Services with the Fourth Industrial Revolution

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**Abstract**

*The Fourth Industrial Revolution (4IR) is driven by developments in ICTs particularly emerging digital technologies that blur the boundaries between physical, digital and biological systems. Such digital technologies include the Internet of Things (IoT), Artificial Intelligence (AI), Cloud Infrastructure, or cloud computing, big data analytics, Nanotechnologies, Advanced Robotics, Sensors, Blockchain and 3D Printing. ICT developments and 4IR technologies in particular, have impacted the conventional library processes, activities and services. All these continue to add value to libraries in diverse ways. There are numerous examples where 4IR technologies have been integrated into library systems. There are also many trends and opportunities fostered by emerging technologies and other compelling characteristics of 4IR. As a result, libraries are required to develop strategies to enable them respond to the demands, challenges and disruptive changes of the 4IR environment. This includes the need for libraries to re-examine the management and delivery of their services to proactively invest in ICTs, continuously evolve, become innovative and realign their practices. The new library philosophy in the 4IR era is "access rather than ownership". There is a call for paradigm shift and for librarians to continuously acquire new skills to fit well in the changing work environment. LIS education systems must change their programmes and curricula to provide sufficient content and practices that will produce librarians with the necessary competencies. Moreover, continued capacity building and awareness raising is necessary among leaders and decision makers in the library sector.*

**Keywords:** Fourth Industrial Revolution, 4IR, ICTs, library services

**Introduction**

The First Industrial Revolution that spanned from 1760 to 1840 was triggered by the construction of railways and discovery of the steam engine. It was mostly confined to Britain. It was responsible for transition from manual labour to machines. It used water and steam power to mechanise production. The Second Industrial Revolution, from 1900 to 1960, was made possible by electrification which enabled mass production. The Third Industrial Revolution, which is regarded as the computer or digital revolution, began in 1960s. It was catalysed by the invention of computers and the internet which enabled automation of production (Schwab, 2016; Pozdnyakova et al., 2019). The World has now entered the Fourth Industrial Revolution which is also known as Industry 4.0 or 4IR. The term "Industry 4.0" was first coined at the Hanover Fair in Germany in 2011 to denote business processes in industry that envisage organisation of global production networks based on new information and communication technologies (ICTs) (Schwab, 2017). The 4IR is building on the Third Industrial Revolution and it is characterised by a fusion of technologies that blur the boundaries between physical, digital and biological spheres. In other words, the 4IR is characterised by unprecedented developments in digital, physical and biological technologies and the convergence of their applications. It is unprecedented in terms of its scale, scope and complexity (WEF, 2016). The 4IR is happening at different pace across countries, sectors and organisations around the world and it strongly impacts all aspects of human life.

Technologies that drive 4IR include the Internet of Things (IoT), Artificial Intelligence (AI), Cloud Infrastructure or Cloud Computing, Big Data Analytics, Nanotechnologies, Advanced Robotics, Sensors, Blockchain and 3D Printing (Figure 1).
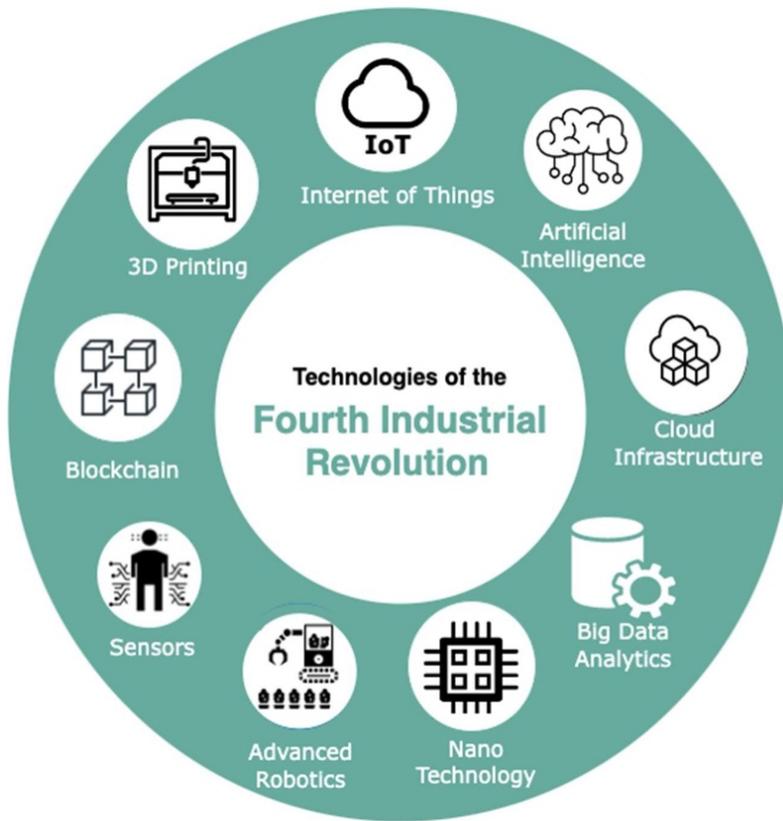
**Figure 1: Common 4IR Technologies**

*Source*: **Authors' Construct (2021)**

The Internet of Things (IoT) describes a connection of such different devices as computers, sensors, refrigerators, washing machines, television sets, vehicles and mobile phones which are made possible by digital technologies (Kayembe & Nel, 2019). It is estimated that by the end of 2021, there were 35.82 billion IoT devices installed worldwide and there will be 75.44 billion devices by 2025 (Steward, 2021). Artificial Intelligence (AI) is a technology used in simulating the thinking and behaving process of human beings. It is the ability of computers to perform tasks normally requiring human intelligence such as visual perception, speech recognition, decision-making and translation between languages (Pfeifer & Scheier, 2001). Cloud infrastructure or cloud computing includes ICT resources that offer storage and processing capabilities in virtual system by serving multiple users. It involves software applications (software-as-a-service), computing power or storage space (infrastructure-as-a-service) and a platform

on which developers can build and deploy applications (platform-as-a-service) (Ndung'u & Signé, 2020). The concept of Big Data applies to large, diverse and complex datasets that are growing exponentially with time. These are either structured, semi-structured, or unstructured data that cannot be stored or processed efficiently using traditional data management tools (Golchha, 2015). Nanotechnology encompasses the fabrication and application of chemical, physical and biological systems at scales ranging from individual molecules or atoms to submicron dimensions. Not only that but also it includes the integration of these resulting nanomaterials into larger systems (Bayda et al., 2020). This advanced field of research and application is enabled by advanced digital technologies. Robots are programmable machines which are usually able to carry out a series of actions autonomously or semi-autonomously (Owen-Hill, 2017). There has also been humanoid robot such as "Sophia the Robot" who can speak at conferences, attend events and meet people (Retto, 2017). Blockchain is a protocol where a network of computers collectively verifies a transaction by enabling people who do not know each other to collaborate without having to go through a neutral central authority. An example of Blockchain application is digital currencies such as Bitcoin in which Blockchain technology records financial transactions made with Bitcoin (Swab, 2016). 3D Printing is a technology that creates physical objects into a three-dimensional shape by printing layer upon layer from a digital 3D Drawing or Model (Alsulaimani & Islam, 2022).

**Libraries and Information Services in the Fourth Industrial Revolution**
Libraries and information services have been going through various phases of development; most of which are triggered by advancements in ICTs. For example, the automation systems in libraries started in 1960s with Machine-Readable Cataloging (MARC) development process. In 1990s, libraries developed Online Public Access Catalog (OPAC), audio-visual media systems and web-based indexes. At the same time, there were developments and application of CD-ROMs, full-text databases and the Internet and the Web which disrupted some of technologies used since 1960s (Lewis, 2007).

ICT applications have improved such conventional library processes, activities and services as cataloguing, circulation, current awareness and reference services, bibliographic services, document delivery, interlibrary loans, customer relations

and audio-visual services. According to Raju (2014), new ways of scholarly communication, the immense use of mobile devices, the expansion of virtual spaces for libraries and the proliferation of social media have collectively affected the traditional role of libraries. ICTs have transformed libraries from just being a physical structure housing information resources to online collections that can be accessed globally (Ocks & Gabriel, 2021). The worry that ICT developments would devalue library and information services and perhaps the demise of the library and information science (LIS) profession is no longer valid because it is now well known that these technologies increasingly add value to libraries in diverse ways and that the profession itself is evolving.

There are numerous examples where 4IR technologies have been integrated into library and information services. For instance, Smith (2019) as cited by Chigwada and Chisita (2021) reported an advanced robotic conveyer system that transports books from Bryant Park off-site storage area to New York Public Library underground. Some libraries are collecting and analysing data using social media tools, drones, cameras and other digital devices. The University of Pretoria employed Libby, a client service robot in May 2019 for providing guidance, to conduct surveys, display marketing videos and answer questions (Chigwada & Chisita, 2021). Libchain was developed to contain information on how books are often passed on between users, loaning period and home library of the book. Libchain leverages on Blockchain technology in charging and discharging whereby potential borrowers alert the borrowers of the books to pass the books to the potential borrower after usage (Cabello et al., 2017). Among other uses, IoT is expected to be used for self-checkout in libraries, taking stock of information resources, access control in the physical building, tracking assets, monitoring the library network (Ayinde & Kirkwood, 2020).

Nkiko and Okuonghae (2021) describe some important trends and opportunities fostered by emerging technologies of which libraries and information services must embrace and align themselves. These include the following:

i.    *Artificial Intelligence and Robotics:* AI technologies are being deployed to facilitate a wide variety of services and resources to library users. AI applications in libraries include automated indexing and abstracting, expert system reference services, cataloging and classification. Some

libraries have automated storage and retrieval systems, autonomous shelf reading robots, humanoid robots, Chatbots and voice activated systems. The Chatbottechnology enables automated conversations between library users and a machine. There is also a speech-to-text-to-speech service where a user explains to the robot their information needs and it uses machine-made indexes to locate potential contents.

ii. *New Library Spaces:* Libraries in the 4IR era are supposed to provide a welcoming, conducive, secure, serene, aesthetic and common space that is technologically enabled. The space provided by libraries should engender inspiration, reflection, creativity, innovation and exchange of ideas. Such libraries are expected to reconfigure their physical spaces to suit current realities of fostering learning, sharing, communication and collaboration. There should be inclusion of supportive and communal environment that allows for a group study by like-minded persons, dealing with similar issues and related problems. There should also be research spaces dedicated to postgraduate students and researchers. Such spaces should consist of technological resources, seminar rooms, teleconferencing facilities, areas for discussion and relaxation as well as those offering services which directly support research endeavours.

iii. *Robust Hybrid Library Collection:* Libraries should continue to operate in a hybrid environment integrating the traditional and the digital as one. Collection development should provide a broad range of contents in formats accessible to the broadest possible spectrum of end users. It is imperative, therefore, that the library provides varied, authoritative, up-to-date and excellent materials to meet the information needs of users. Libraries as gateways to knowledge now subscribe to electronic databases containing a plethora of electronic books and journals. They also facilitate access to the global information networks and curated information resources such as videos, case studies, company profiles, magazines and thesauri.

iv. *Virtual Operations and Full Automation:* The Web Online Public Access Catalogue now replaces the traditional card catalogue by enabling remote login to the library catalogue on the cyberspace through a Universal Resource Locator (URL). Virtual library provides access to databases

containing electronic books, journals, theses, dissertations, alert services and electronic document delivery. It also provides such online transactions as renewal of loans, reserving items, booking rooms and equipment, online chat services and online tutorials. Automation of library routines and processes include the installation of automatic doors, tele lift to deliver books to several floors, biometric systems, provision of self-service machines with RFID functionality, electronic security gates, CCTV, automated bindery system, the use of scanners and beacon application as well as automatic book sorters.

v. *Research Data Management (RDM):* RDM involves storage of full dataset files, preservingand keeping sensitive data secure as well as scanning research data recorded on paper to be kept in digital formats. All raw data in the collection are curated to increase access andare assigned object identifier (DOI). Different institutional policies must provide necessaryguidelines for data sharing and reuse as well as requirements for removal (Tenopir *et al.*, 2014).

vi. *Open Scholarly Communication:* According to UNESCO (2015), open scholarly communication is a process of sharing, disseminating and publishing research findings conducted by researchers for its free availability to the global communities. It is the responsibility of a library in the 4IR era to ensure global visibility and unhindered access to its institutional intellectual productivity and all scholarly outputs. The libraries advance this objective through institutional repositories, Open Educational Resources (OER) and influencing faculty members to publish in reputable open access outlets.

vii. *Bibliometrics:* This relates to understanding and evaluating the patterns, impact, relevance,influence direction and utility of research outputs. One of the major parameters in the global ranking of universities is the volume of research output and citations. For instance, the Times Higher Education (THE) relies on metrics provided by the Scopus database. Issues of impact factor, citation index, visibility on such social web platforms as Google Scholar, Mendeley, ResearchGate, Zotero, Academia.edu and Almetrics should be thoroughly understood by all academic staff through the intervention of the university library.

## What Should be Done to Align Libraries and Information Services with 4IR?

The 4IR environment brings with it disruptive and transformative opportunities and technologies that require appropriate strategies to align to the new environment. The new environment requires libraries to re-examine the management and delivery of their services so that they can proactively invest in ICTs, continuously evolve, become innovative and align their practices. Lichterman (2011) reports a concern for some librarians who consider ICTs as potential threats to the importance of library, its resources and its personnel. Fortunately, this is not the case because ICTs have significantly redefined the library's place in society.

There is no doubt that traditional library buildings and libraries as institutions will continue to exist for many years although their roles will continue to change. Xing and Marwala (2017) call for the reimagining of libraries to embrace a combination of physical and virtual environments that facilitate access to information. Similarly, Islam and Islam (2015) argue that technology should form part of the library's internal environment rather than replacing it. This will enable development of smart libraries that keep abreast with smart technologies. The new approach in the 4IR era is "access rather than ownership", meaning that libraries should no longer be interested in collecting everything required by their users. Emphasis should be put on providing access to information resources, regardless of their location, in whatever format, as and when they are needed. Penniman (1993) stresses that libraries must aim at the delivery of information rather than its storage and that they should be evaluated based on services delivered not assets controlled.

Implementing and integrating ICTs within library functions and services has led to, among other things, a shift in work patterns, a need for new skills and a reclassification of positions and job retention in libraries (Ukachi, 2014). There is a call for paradigm shift among librarians to continuously acquire new skills to fit well in the changing work environment. According to Manda and Backhouse (2017) as cited in Chigwada and Chisita (2021), librarians in the 4IR era should be skilled, innovative and technologically knowledgeable. Deloitte (2018) stresses that the attributes required among the 4IR librarians are agility, resilience, responsiveness and adaptability. Hysa and Juznic (2013) suggest that librarians should enhance their computer competencies, allowing them to keep up to date with the necessary knowledge and skills required in this digital era.

LIS education systems are urged to change their programmes and curricular to provide sufficient content and practice that will produce librarians with the necessary competencies (Hysa & Juznic, 2013). There is also a challenge of overreliance on ICT personnel from outside the libraries with little or no orientation in library services and practices. LIS education systems should produce librarians with sufficient ICT skills to design and manage appropriate library systems. On the other hand, libraries should also promote digital literacy among their users so that they can access and use information resources using various technologies. Librarians should also deal with challenging issues such as how to handle the information overload, how to conduct sound research and manage big data as well as dealing with predatory publications and publishers. Since innovation is key in the 4IR, libraries should invest in research and development (Manyika *et al.,* 2017).

Ayinde and Kirkwood (2020) explain the 10 skills predicted by WEF 2016 that will be needed by, among others, information professionals, to thrive in the 4IR. The 10 skills are:

i.  *Sense making*: This is the ability to make deeper meaning of what is expressed. It is argued that the 4IR technologies can do a lot of things, but all is GIGO. Librarians can answer users' queries more exactly.

ii.  *Social intelligence*: The ability to bring deep connection to users to stimulate reactions and desired interactions. Librarians should be able to study the attitude and behaviour of users which machines could not do.

iii.  *Novel and adaptive thinking*: Being innovative and creative by going extra miles in meeting the user's needs. Information professionals should apply convergent or divergent thinking (different approaches to innovation and connections of ideas) to provide solutions.

iv.  *Cross-cultural competency*: Readiness to work with different ages such as kids and the old.

v.  *Computational thinking*: Turning a large amount of data into abstract concepts and to understand databased reasoning (Burrus et al., 2017; Cansu & Cansu, 2019).

vi.  *Transliteracy*: To acquire, create, analyse, process, evaluate and use all categories of information, engage and persuade their users.

vii.    *Transdisciplinary*: This means understanding concepts across multiple disciplines. Information professionals should team up with different departments or organisations to improve and rethink about ways of rendering services better to effectively meet users' needs.

viii.   *Design mindset*: This involves farsightedness, an open and clear mind for learning and the ability to adopt and adapt to any situation to survive in 4IR.

ix.     *Cognitive load management*: This has something to do with the amount of load the brain can retain. The ability to make informed judgment despite information overload in meeting the users' information needs.

x.      *Virtual collaboration*: The world is experiencing virtual collaboration which helps to break barriers in communication whereby two or more people can collaborate without physically coming together. This entails the ability to use technologies such as webinar or zoom to facilitate virtual collaboration.

Other important things to consider include continued capacity building and awareness raising among other actors in the library sector. This is because some leaders and decision makers in many libraries in Africa still show aversion toward adapting to a digital environment. Overcoming such aversion will lead to adequate funding of libraries, which is one of the biggest challenges. Smart leadership is also necessary to overcome constraints such as low bandwidth, poor network systems, inadequate requisite hardware and software, cybersecurity risks and interrupted power.

**Conclusions**

The 4IR is driven by smart technologies such as IoT, AI, Cloud Infrastructure, Big Data Analytics, Nano Technologies, Advanced Robotics, Sensors, Blockchain and 3D Printing. The world has already entered this era which is largely characterised by rapid changes. The changes are both disruptive and transformative and they are unavoidable. ICT applications have improved the conventional library and information processes, activities and services and transformed libraries from just being physical structures to online collections for global access. Generally, ICTs are adding value to library and information services in diverse ways. There are numerous examples where 4IR technologies have been integrated into these systems. There are also many trends and opportunities fostered by emerging technologies and other compelling characteristics of 4IR.

Libraries and information services are required to develop strategies that will enable them respond to the demands, challenges and disruptive changes of the 4IR environment. This includes the need for libraries to re-examine the management and delivery of their services to proactively invest in ICTs, continuously evolve, become innovative and align their practices. Technology is forming part of the library's internal environment rather than replacing it. The new philosophy in the 4IR era is "access rather than ownership". ICTs have significantly redefined the library's place in society hence there is no need for some librarians to consider ICTs as potential threats to the importance of library, its resources and its personnel. There is a call for paradigm shift and for librarians to continuously acquire new skills to fit well in the changing work environment. There are numerous skills that are needed by librarians to thrive in the 4IR. LIS education systems must change their programmes and curricula to provide sufficient content and practices that will produce librarians with the necessary competencies. Moreover, continued capacity building and awareness raising is necessary among leaders and decision makers in the library sector in order to overcome constraints such as inadequate funding, low bandwidth, poor network systems, inadequate requisite hardware and software, cybersecurity risks and interrupted power supply.

## References

Alsulaimani, B., & Islam, A. (2022). Impact of 4IR technology and its impact on the currentdeployment. *arXiv preprint arXiv:2209.01791*.

Ayinde, L., & Kirkwood, H. (2020). Rethinking the roles and skills of information professionalsin the 4th Industrial Revolution. *Business Information Review*, *37*(4), pp.142-153.

Bayda, S., Adeel, M., Tuccinardi, T., Cordani, M., & Rizzolio, F. (2020). The history of nanoscience and nanotechnology: from chemical–physical applications to nanomedicine. *Molecules,* 25(1), 112.

Burrus, J., Mattern, K., Naemi, B. D., & Roberts, R. D. (eds.) (2017). *Building better students:Preparation for the workforce*. Oxford University Press.

Cabello, J., Janßen, G. & Muhle, A. (2017). Distributed library management system based onthe blockchain technology. Atos IT Challenge.

Cansu, S. K., & Cansu, F. K. (2019). An overview of computational thinking. *InternationalJournal of Computer Science Education in Schools,* 3(1):1

Chigwada, J. P., & Chisita, C.T. (2021). Introduction to the Fourth Industrial

Revolution andLibraries. In: *Examining the Impact of Industry 4.0 on Academic Libraries*. EmeraldPublishing Limited.

Deloitte. (2018). Preparing tomorrow's workforce for the Fourth Industrial Revolution. For business: A framework for action. Available at: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/About-Deloitte/gx-preparingtomorrow- workforce-for-4IR.pdf.

Golchha, N. (2015). Big data-the information revolution. *InternationalJournal of Advanced Research,* 1(12):791-794.

Hysa, B., & Juznic, P. (2013). Agents of change: Regional cooperation and LIS education andtraining. Singapore, IFLA.

Kayembe, C., & Nel, D. (2019). Challenges and opportunities for education in the FourthIndustrial Revolution. *African Journal of Public Affairs,* 11(3), 79-94.

Lewis, D. L (2007). A strategy for academic libraries in the first quarter of the 21st century. *College and Research Libraries.* 1: 68 (5) 418-434.

Lichterman, J. (2011). The 21st Century Library: Books may gather dust in the stacks, butlibrarians are busier than ever. The Michigan Daily. Accessed from https://www.michigandaily.com/news/changing-libraria.

Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R., & Sanghvi, S., (2017). Jobs lost; jobs gained: Workforce transitions in a time of automation. *McKinseyGlobal Institute*, *150*.

Ndung'u, N., & Signé, L. (2020). The Fourth Industrial Revolution and digitization willtransform Africa into a global powerhouse. Foresight Africa Report.

Nkiko, C., & Okuonghae, O. (2021). Achieving the 4IR University Library in Sub-SaharanAfrica: Trends, Opportunities and Challenges. *Folia Toruniensia*, *21*, pp.121-140.

Ocks, Y., & Gabriel, O. (2021). The Use of Information and Communications Technologies byLibrary Users at the University of the Western Cape. *Mousaion*, *39*(3).

Owen-Hill, A. (2017). What's the Difference Between Robotics and Artificial Intelligence?'. *Obtained from: https://blog. robotiq. com/whats-the-difference-between-robotics-and-artificial-intelligence*.

Penniman, W. D. (1993). Shaping the future for libraries through leadership and research. *Libraries and the future: Essays on the library in the twenty-first century.*

Pfeifer, R., & Scheier, C. (2001). Understanding intelligence. MIT press.

Pozdnyakova, U. A., Golikov, V.V., Peters, I. A., & Morozova, I. A. (2019). Genesis of the revolutionary transition to industry 4.0 in the 21st century and overview of previousindustrial revolutions. In Industry 4.0: Industrial Revolution of the 21st Century (pp.11-19). Springer, Cham.

Raju, J. (2014). Knowledge and skills for the digital era academic library. *The Journal ofAcademic Librarianship,* 40(2): 163-170

Retto, J. (2017). Sophia, first citizen robot of the world. ResearchGate, URL: https://www.researchgate.net.

Schwab, K. (2016). The Fourth Industrial Revolution. New York: Crown Business.

Schwab, K. (2017). The fourth industrial revolution. Moscow, 2016. http://www.litres.ru/pages/biblio_book/?art=21240265&lfrom=1594811 97. AccessedOctober 21, 2017.

Steward, J. (2021). The Ultimate List of Internet of Things Statistics for 2021. https://findstack.com/internet-of-things-statistics/

Tenopir, C., Sandusky, R. J., Allard, S., & Birch, B., (2014). Research data management services in academic research libraries and perceptions of librarians. *Library & Information Science Research*, *36*(2), p.84-90.

Ukachi, N. B., Onuoha, U. D., & Nwachukwu, V.N. (2014). Students' Attitudes as a Determining Factor to Electronic Information Resources Use in University Libraries in South-West, Nigeria. DESIDOC Journal of Library & Information Technology, 34(4) p.333-341.

World Economic Forum. (2016). The future of jobs: Employment, skills and workforce strategyfor the fourth industrial revolution. Global Challenge Insight Report.

Xing, B., & Marwala, T. 2017. Implications of the Fourth Industrial Age on Higher Education. The Thinker 73:10-15. URL:

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3225331