Library Management

Assessing the alignment of a University of Technology Library infrastructure with the Fourth Industrial Revolution: implications for librarian roles

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Abstract

Purpose – This study aims to evaluate how well a University of Technology Library's infrastructure aligns with the requirements of the Fourth Industrial Revolution (4IR). By examining the current state of technological integration and identifying potential gaps, this research seeks to provide insights into the necessary developments and adaptations needed. Additionally, the study explores the implications of these changes for librarian roles, highlighting the evolving skill sets and competencies required in this new paradigm.

Design/methodology/approach – The study used a mixed methods research approach, integrating an online questionnaire to gather quantitative data and conducting interviews to obtain qualitative insights. The subsequent interviews offered a thorough understanding of the library's alignment with the 4IR and its implications for the librarians at the library.

Findings – The findings of this research will offer valuable perspectives for university faculties, librarians and policymakers in shaping future-ready library environments that support innovative teaching, learning and research practices.

Practical implications – The findings highlight the need for academic libraries to continuously evolve with enhancements to existing infrastructure to incorporate advancing technologies and encompass modern digital platforms, tools and resources to support innovative teaching, learning, and research works.

Originality/value – This study provides insight into the results of the importance of evolving with the advances of technologies in academic institutions within a developing country in Africa.

Keywords Library infrastructure, Academic librarians, Fourth Industrial Revolution, Technological developments, Librarian roles

Paper type Research paper

Introduction

The advent of the Fourth Industrial Revolution (4IR) is "characterized by a fusion of technologies blurring the lines between the physical, digital and biological" realms (Maynard, 2015, p. 1005). As academic libraries stand at the forefront of knowledge dissemination and research, the imperative to adapt and align their infrastructures with 4IR becomes paramount. This technological transformation not only redefines the educational landscape but also reshapes the roles and responsibilities of librarians within these institutions (Moonasar, 2024, p. 235).

In this era, libraries are no longer merely repositories of books and journals but dynamic hubs of digital information and innovation. The integration of advanced technologies such as artificial intelligence (AI), machine learning and big data analytics into library systems can significantly enhance the accessibility, efficiency and user experience of library services (Balashova and Gromova, 2018, p. 1). However, this change requires a thorough assessment of the current library infrastructures to ensure that they meet the demands of the 4IR.

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Fourth Industrial Revolution (4IR)

The 4IR refers to the ongoing transformation of traditional manufacturing and industrial practices with the integration of digital technologies. According to (Schwab, 2017, p. 8; Maynard, 2015, p. 1005), 4IR represents a fusion of technologies that blur the lines between the physical, digital and biological realms. Key components of 4IR include AI, robotics, the Internet of Things (IoT), 3D printing, nanotechnology, biotechnology, quantum computing and others. This revolution is portrayed by the rapid technological advancements that change the way we live, work and interact. It has impacted various sectors, including manufacturing, healthcare, transportation, energy and beyond. 4IR facilitates automation, data-driven decision-making, personalized products and services, and enhances connectivity (Schwab, 2017, p. 8). 4IR, however, comes with challenges such as job displacement due to automation, raises concerns about data privacy and security, and highlights the digital divide between those with access to technology and those without (Ghislieri *et al*., 2018, p. 2).

The importance of libraries in supporting 4IR

Libraries play an important role in supporting the 4IR by providing access to information, fostering digital literacy and promoting lifelong learning. Libraries serve as a repository of knowledge, providing access to a wide range of resources, including books, journals, databases and digital archives. In the era of 4IR, where there is an overload of information that is rapidly evolving, libraries play an integral role in curating and organizing content to assist users in navigating and making sense of the digital landscape (Hussain, 2020, p. 4). As technology becomes increasingly integrated into daily life and work, digital literacy skills are essential and libraries can offer training programs, workshops and resources to help users develop digital skills such as coding, data analysis and information literacy. These skills are essential for individuals to thrive in the 4IR digital economy. In the face of the digital divide, where there are disparities in access to technology and the internet, libraries can play a vital role in bridging this gap. Many libraries provide free access to computers, high-speed Internet and other digital tools, ensuring that everyone, regardless of socioeconomic status, has the opportunity to participate in the digital world (Frederick, 2019, p. 14). Libraries serve as hubs for creativity and innovation, providing spaces for collaboration and experimentation. Additionally, libraries offer collaboration spaces such as MakerSpace and FabLabs which are equipped with technologies such as 3D printers, laser cutters and robotics kits, empowering users to turn their ideas into reality and engage in hands-on learning experiences (Ocholla and Ocholla, 2020, p. 358). Libraries also play an important role in maintaining and providing access to cultural heritage materials. Librarians are involved in digitizing and preserving historical documents, photographs and other artifacts, ensuring their long-term preservation and accessibility for future generations.

Basically, libraries are essential in supporting 4IR by providing access to information and technology, fostering digital literacy and skills development, promoting innovation and creativity and preserving cultural heritage. They serve as invaluable community resources that empower users and contribute to the advancement of society in the digital age.

The purpose of the study

The aim of this study was to assess whether the current infrastructure of the Durban University of Technology (DUT) library supports the 4IR and the changing roles of librarians and to introduce a model of aligning librarians' roles and skills with the 4IR.

Research methodology

The DUT is a multi-campus university with six site libraries spread throughout the province of KwaZulu-Natal. This study used a mixed-method research strategy that combined qualitative and quantitative methodologies. Data were collected through a self-assisted online

questionnaire and followed by interviews. Many researchers use both questionnaires and interview techniques to gather information for the studies (Hilton *et al*., 2020, p. 187). Incorporating both quantitative and qualitative methods increased the credibility of the research results. While the quantitative method provided statistical information, the qualitative approach delved into complex and comprehensive data, providing the researcher with a deep understanding of the interactions of the participants. By employing mixed methods research, the findings were triangulated, with diverse data sources cross-referenced to authenticate and substantiate the conclusions (Creswell and Creswell, 2018, p. 15; Maree, 2016, p. 2).

The population sample focused on the 70 library staff employed at the DUT library. The follow-up interview was conducted with 10 library staff. Purposive sampling was used for this study, as it allowed researchers flexibility and engaged their own informed knowledge to select the sample from the population group (Blackstone, 2018, p. 80). The 10 librarians identified and chosen for the interviews were based on their availability, location and interest in the effects of new technology and innovations on the library environment and the impact on the evolving roles and responsibilities of librarians.

Literature review

The Fourth Industrial Revolution (4IR)

The 4IR impacts significantly on academic libraries, by transforming many aspects of their operations and services. 4IR has digitally transformed libraries with the accelerated digitization of library collections and resources. Academic libraries have increasingly moved towards digital formats for books, journals and other materials, making them accessible online to users. This has expanded access to information and enabled libraries to reach a broader audience. Advanced 4IR technologies such as AI, machine learning and big data analytics are being integrated into library systems and services (Hussain, 2020, p. 3; Tella *et al*., 2022, p. 552). These technologies are used for tasks such as cataloging, organizing information, personalizing recommendations and enhancing user experiences. Remote access and virtual services have increased the volume of online learning and remote work, and academic libraries have adapted accordingly by offering virtual services and resources. This includes virtual reference services, online workshops and tutorials and remote access to electronic resources (Ayinde and Kirkwood, 2020, p. 150). Libraries have also invested in technologies that support remote access, such as virtual private network (VPN) and cloud-based platforms. Academic libraries are following the trend to transform their physical spaces to accommodate the changing needs of users in the 4IR. Many libraries now offer collaborative spaces equipped with technology for group work, multimedia production and presentation. Makerspaces and collaborative spaces, which provide tools and resources for hands-on learning and creation, have also become increasingly common in academic libraries (Ocholla and Ocholla, 2020, p. 361). With the move to make information more accessible, the openness of educational resources has been highlighted and 4IR has increased the growing emphasis on open access to scholarly information and educational resources. Academic libraries play a crucial role in supporting open-access initiatives by providing platforms for hosting and disseminating scholarly research, as well as promoting the use of open educational resources (OER) to reduce the cost of textbooks and course materials (Ocholla and Ocholla, 2020, p. 365). The rise of big data and computational research methods has created new challenges and opportunities for academic libraries. Libraries are increasingly involved in assisting researchers with data management, curation and preservation. They also support digital scholarship initiatives by providing access to specialized software tools, datasets and research support services (Ahmad *et al*., 2019, p. 204).

Overall, the 4IR has prompted academic libraries to adapt and innovate in order to remain relevant in a rapidly changing information landscape. By embracing new technologies, reimagining their services and collaborating with stakeholders, academic libraries continue to play a vital role in supporting teaching, learning and research in higher education.

Role of libraries and librarians in the 4IR era

With 4IR, libraries and librarians play an integral role in ensuring equitable access to information, promoting digital literacy, supporting lifelong learning and facilitating the integration of emerging technologies into institutions and communities. Librarians are actively involved in providing access to information and curating data for ease of retrieval. Academic libraries continue to serve as repositories of knowledge and information. Librarians curate collections, both physical and digital, ensuring access to reliable and diverse resources amidst the overwhelming abundance of information available online. With the proliferation of digital technologies, librarians are vital in promoting digital literacy skills and assisting users in navigating online resources, evaluating information credibility and mastering digital tools necessary for participation in the digital environment. Librarians provide training and support for users to leverage emerging technologies effectively (Ahmad *et al*., 2019, p. 204). This includes workshops on programming, coding, data analytics, virtual reality, 3D printing and other skills relevant to the 4IR environment. In an increasingly digital society, libraries play an integral role in bridging the digital divide. Librarians ensure that users can access information seamlessly and provide users with the information and digital literacy skills needed to navigate the digital landscape. Librarians advocate for privacy rights and ethical use of information in the digital age. They educate users on data privacy concerns, empower them to navigate the virtual environment safely and uphold principles of intellectual freedom and information ethics (Fernandez, 2020, p. 223). In the current environment, libraries serve as hubs for innovation and community engagement. Librarians facilitate programs and events that encourage creativity, problem-solving and collaboration among users and surrounding communities. They also foster partnerships with local businesses, schools and technical organizations to bring innovative projects and resources to the community. Libraries and librarians adapt to the changing technological landscape of the 4IR era by continuing to serve as trusted sources of information, fostering digital literacy and innovation, and promoting equitable access to knowledge and resources for all members of the communities they serve.

Evolution of librarian roles in the digital age

The 4IR has brought about significant changes in various sectors, including libraries. The role of librarians has evolved significantly in the digital age, driven by advancements in technological innovations and changes in information consumption habits of users that are brought about by the demands of 4IR. Traditionally, librarians were mainly information curators and were primarily responsible for cataloging and organizing physical materials such as books and journals (Han and Hswe, 2011, p. 129). In the 4IR, librarians still curate information, but now they also manage digital resources, including databases, e-books, online journals and multimedia content. Librarians are now advocates for digital literacy and play a crucial role in promoting digital literacy skills among users. The librarians help users navigate digital resources, evaluate online information for credibility and teach digital research skills (Hamad *et al*., 2020, p. 3). In the 4IR, librarians are basically technological integrators as they integrate technology into library services and resources to enhance access and participation. This may involve implementing digital cataloging systems, offering virtual reference services, providing access to online databases and utilizing technologies like virtual reality or augmented reality for educational purposes. In the 4IR era, librarians are expected to collaborate with other institutions, community organizations and stakeholders to provide innovative services and programs. Traditionally, librarians were expected to advocate and impart information literacy instructions to users. With the abundance of information available online, librarians play a crucial role in teaching information literacy skills. They help users evaluate the credibility and reliability of online sources, navigate databases and use search engines effectively to find relevant information. Librarians now assist researchers with research inquiries by guiding them through the research process, recommending relevant resources and providing instruction on citation management tools. Librarian roles have

evolved and they now collaborate with faculty to support research initiatives and provide specialized research services tailored to the needs of academic departments (Wójcik, 2016, p. 409). In the rapidly changing landscape of 4IR, continuous learning and development is essential. Librarians serve as facilitators of lifelong learning by offering access to educational resources, online courses and workshops on emerging technologies, career development and other relevant topics (Mooko and Oladokun, 2021, p. 226). With the growing emphasis on data-driven decision-making, librarians are increasingly involved in managing and analyzing data. Librarians assist researchers and users in locating, accessing and interpreting data sets, as well as providing guidance on data management best practices and ethical considerations. Additionally, the roles of librarians in the 4IR are more dynamic and multidimensional than their previously traditional roles. Librarians in the 4IR landscape continue to fulfill their traditional roles as custodians of information while adapting to the evolving needs and preferences of users in an increasingly digitally innovative world. They remain essential guides and facilitators in the pursuit of knowledge and information literacy.

Library infrastructure

Our daily lives and environment is constantly being reshaped by 4IR. It is revolutionizing productivity through automation and making information technologies indispensable for businesses. Libraries worldwide are being impacted by advances in information and communication technology (ICT), which affect their hardware and information technology (IT) infrastructure, including networks, servers, applications, bandwidth and information sources. Concepts like cloud computing, digital transformation and the IoT are prompting users, communities and academic institutions to adapt. Selecting the right software can offer cost-effective solutions and potentially save libraries from additional expenses (Abo-Seada, 2019, p. 19).

Abo-Seada (2019, p. 19) outlines around ten fundamental elements necessary for the modernization of academic library infrastructure, including hardware such as computers, printers and accessories; software programs and applications; local and wide area networks (LAN/WAN) along with the internet and VPN services; integrated library systems (ILS) managing collections and user accounts; electronic tools, websites, and social media platforms; databases; electronic and digital resources; staff and user training materials; and administrative departments overseeing system management. It's crucial for academic libraries to align their ICT strategies with those of their parent institutions and ensure their infrastructure can support innovative library services. Marwala (2020) highlights that the software-based, data-driven, and cloud-based foundations are required to underpin the 4IR. Digital and online structures enhance information access, transparency, and community connectivity. Given the energy demands of data and computing technologies, a reliable power source is essential to sustain 4IR initiatives. Both the country and the hosting institution need robust maintenance plans to support 4IR initiatives effectively. Institutions and academic libraries should explore setting up cloud computing infrastructure and ample storage space to accommodate big data projects and computing requirements.

Hardware

Computer hardware includes the physical components and devices necessary for a computer system to execute various functions, processing data, executing instructions and providing a platform for software applications. These components, both internal and external, collaborate to facilitate the functioning of a computer system. Key components typically include the central processing unit (CPU), the motherboard, which serves as the main circuit board connecting power flow to other components, as well as the random access memory (RAM) and storage space. The 4IR is characterized by rapid technological advancements, emphasizing the digitization of library resources for streamlined information access. In this period, substantial volumes of structured and unstructured data, is considered the new commodity, which require

dedicated hardware storage solutions. Institutions and libraries routinely generate data, underscoring the need for sufficient storage capacity. Computers, servers and central processing units are indispensable for ongoing data backup. However, many institutions in South Africa, similar to the DUT library, face challenges in acquiring these technically advanced hardware due to financial constraints (Kayembe and Nel, 2019, pp. 84-90).

Computer software

According to Tella (2020, p. 1), it is imperative for libraries to possess current and applicable software packages to retain their relevance and functionality in the context of the 4IR. To adapt and thrive in this era, libraries require both suitable software solutions and proficient staff. The primary focus lies in acquiring software capable of efficiently managing and facilitating user access to required information, meeting the evolving needs of library users. Computer software encompasses programs, instructions and data essential to enable a computer system to perform various functions and tasks.

Description of the DUT library

The DUT library is a multi-campus spread across Durban and Pietermaritzburg and comprises six library sites. The university is currently upgrading its infrastructure to accommodate the evolving changes in ICT. The university ICT enablers are now cloud-based and the DUT library systems are dependent and supported by the university infrastructure. The DUT library is striving to respond to the changing needs of the users and the university environment and is striving towards accommodating the innovative changes that impact the functionality of the library. The strategic drive for the university is currently to promote innovation and fluidity among the staff. One of the main aspects of the DUT Strategic plan is for the university to produce staff and students that are adaptable and can rise to meet the changes and challenges in a constantly fluid environment (Envision 2030). The library is ensuring that the library's strategic drive is aligned to the university strategic plan by upgrading the infrastructure and embracing new innovations. Librarians are encouraged to participate in various activities that can allow them to evolve with the changes.

Technological developments at the DUT library

The DUT library is not averse to embracing new technological innovations and is attempting to equip the library with new technology that can assist in providing quality services to users. One of the main and most common challenges that many academic libraries face is budgeting and financial woes. The DUT library is trying as much as possible to keep abreast with changes. The library has implemented RFID (Radio Frequency Identification) on the information resources at all six site libraries. This is to help with inventorying and self-checkout units. This helped to facilitate faster circulation of materials and allows users to manage their own loans. Self-check units have been installed at all six library sites. Duncan (2021:11) explains how the RFID implementation in the Caribbean libraries helped with security, circulation of resources, inventorying and with user self-services. The DUT library has established a MakerSpace in one of the site library to enable and encourage creativity and collaboration among the various faculty units of students and staff. The MakerSpace is a shared workspace that allows individuals to come together to collaborate, share resources and work on projects (Wang *et al.*, 2016, p. 4). The librarians have embraced technology to improve the library services and resources and are constantly embracing ways to integrate new ways of working to improve service delivery for users. The library and librarians are constantly involved in managing the library websites, developing digital repositories and implementing new software systems to assist in cataloging and circulation enhancements. The library has a dedicated library technical unit that provides technical support to users who encounter difficulties accessing resources.

Data management and curation are a continuous attempt by librarians to be involved in data management and curation within the institution. The librarians play a vital role in assisting researchers in managing, organizing and preserving research data in compliance with institutional needs and best practices (Pares and Organisciak, 2023, p. 752). The institutional strategy plans guide each academic library in the pursuit of open scholarly communication and research, which is similar to the position of the DUT library, which is in line with Pares and Organisciak (2023, p. 752).

Findings

A total of 41 librarians responded to the online questionnaire and 10 librarians were individually interviewed to further augment the quantitative data.

Library infrastructure for 4IR

The aim of this study was to assess whether the existing infrastructure at the DUT library aligns with the demands of the 4IR and the evolving roles of librarians. Typically, academic libraries rely on their parent institutions to provide the hardware and software infrastructure necessary to facilitate their operations and systems. In the context of 4IR initiatives, academic library infrastructure often requires cloud-based technology, cutting-edge systems, secure hardware and software. Cloud-based technology assumes a pivotal role in delivering flexibility, scalability and accessibility to library resources and services. It empowers libraries to store and manage large amounts of digital content, foster collaboration with other institutions and provide remote access to users (Wada, 2018, p. 17). Innovative systems encompass a range of technologies, including ILS, digital repositories, discovery platforms and learning management systems, among others, which enhance the library's capabilities and user experience. By investing in and maintaining infrastructure that supports cloud-based technology, innovative systems and secure hardware and software, the DUT library can effectively adapt to the requirements of the 4IR and elevate services to their users. Collaboratively with the university, the DUT library is actively cultivating a culture of research, teaching and learning that fosters creativity and innovation within the academic community.

According to Nkosi *et al*. (2020, p. 2117), infrastructure to support 4IR initiatives extends beyond hardware and software to encompass the employees and facilities required by students in an academic institution. This infrastructure includes physical spaces such as laboratories, library study areas, lecture rooms and other facilities integral to the teaching and learning process.

The DUT library has gradually introduced new technologies, adopting a measured pace to avoid sudden disruptions or excessive attention. This approach has been corroborated by one of the interviewed participants, who stated, *"from my perspective, the direct impact of 4IR technology is currently not evident in any pronounced way. One may assume that once 4IR technologies are fully implemented and operational in all DUT libraries, the impacts will become more apparent."*

In contrast, some interviewed participants showed greater awareness of the new systems, expressing that the DUT library has embraced 4IR and is prepared to continue implementing 4IR innovations.

This is confirmed by the following responses, *"The library is progressing with technology and ensuring that the infrastructure is well-equipped to support various online platforms, such as DSpace, FOLIO (Future of Libraries is Open), library publishing, digital works."*

> There has been lots of investigating, planning and implementation of information and communication technology. The Library has in some instances been the leader in moving in the direction of innovation. The DUT Library has been very progressive.

User engagement in 4IR

The DUT librarians actively engage with library users through various channels, including social media, online platforms and virtual reference services. They seek feedback from users to improve library services and tailor offerings to meet evolving needs. The librarians work to bridge the digital divide of users by providing technology and digital literacy training and access to digital resources. Existing resources, services and technologies are adapted to ensure that users are equipped to continue research. The librarians are aware of the requirements to meet the academic curriculum needs and ensure that the collection of books, journals and digital collections is extensive and easily accessible to the users. The library subscribes to various databases tailored to suit the user's needs and the academic curriculum. The librarians and post-graduate librarians provide research assistance to researchers and users in need of in-depth research help. Regular workshops and courses to teach research skills and how to use library resources effectively are frequently held for users.

Current infrastructure at the DUT library

The library provides study and collaboration seating for individual and group study spaces. There are collaborative workspaces and areas equipped with technology to facilitate group work and projects. The purpose-built spaces are designed to facilitate quiet study, group work and access to resources. The online infrastructure and library management systems provide effective software for cataloging, circulation and managing other library operations. The various digital repositories provide efficient platforms for storing and sharing scholarly works produced by the institution's community.

The library uses EBSCO Discovery Service to provide access to search across library resources. This service is accessible on and off campus through remote access solutions. The university learning management systems allow for integration with platforms like Blackboard and MOODLE to provide seamless access to library resources within the academic framework.

The library MakerSpace is a creative and technology center equipped with 3D printers, scanners and fabrication tools for hands-on learning and creative projects.

The university IT infrastructure provides an adequate network system with the internet and Wi-Fi access throughout the library. The library provides student computers, laptops, tablets, printing and scanning services. Online collaboration platforms and tools like Zoom, Microsoft Teams and Google Workspace for virtual collaboration and learning are available for the DUT community and users. The library has incorporated security systems such as, RFID and security gates, for managing the circulation of physical materials and ensuring the safety of the library's collections.

The findings revealed mixed responses from the respondents, as depicted in Figure 1. The majority of respondents (51%) believe that the current library infrastructure does support the 4IR. This indicates a positive perception of the existing infrastructure's capability to meet 4IR requirements. A significant portion of respondents (25%) feel that the infrastructure supports 4IR to some extent. This suggests that while there are elements in place that align with 4IR, there may be areas that need improvement or further development. While 12% of the respondents believe that the current library infrastructure does not support 4IR at all. This indicates that there are perceived deficiencies or gaps in the infrastructure that prevent it from fully supporting 4IR needs. Another 12% of respondents are unsure about whether the infrastructure supports 4IR. This uncertainty might point to a lack of information or clarity about what constitutes 4IR support within the library infrastructure. Overall, the results suggest a generally positive outlook on the library infrastructure's support for 4IR, with more than half of the respondents affirming its adequacy.

Overview of DUT library infrastructure

On the other hand, some interviewed participants were more perceptive of the new systems and expressed that the DUT library has embraced the 4IR and is prepared to continue

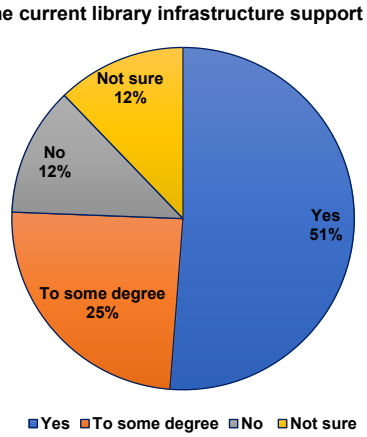

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Figure 1. The current infrastructure

implementing 4IR innovations. This is aligned with Ayinde and Kirkwood's (2020:146) view on this notion, in that new technological innovations have the potential to improve and enhance library services.

As reflected below by the interviewed participants:

> The library is progressing with technology and ensuring that the infrastructure is well equipped to support various online platforms, such as DSpace, FOLIO, library publishing, and digital works.

Another participant concurred with this sentiment, indicating that:

> The library is committed to staying up to date with technological advancements and has improved its systems with new implementations such as FOLIO and EDS. The library is using LibChat to connect with users, has established electronic classrooms, and implemented RFID, embracing new technology packages to assist our clientele.

In response to: What are the 4IR technologies used in the DUT library?

Figure 2 presents the findings of the respondents, and the RFID technology, with a response of 15 (36.59%) seems to be the most widely used or appreciated 4IR technology in the DUT library. RFID is often used for tracking books, streamlining check-in and checkout processes and enhancing security. The higher usage and effectiveness score suggests that it is likely to provide significant value in terms of efficiency and user satisfaction in the library. The open-source library services platform FOLIO with 6 (14.63%) appears to be moderately used or effective. This may indicate that while FOLIO is useful, it might not yet be fully exploited, or there could be some challenges with its adoption or usage. MOODLE (Modular Object-Oriented Dynamic Learning Environment) is a learning management system. A score of 5 (12.20%) suggests that it is somewhat effective for its purpose, likely supporting the educational needs of students and academic requirements. This finding indicates decent usage and satisfaction, but there could be room for improvement. The DUT library discovery tool, EDS (EBSCO Discovery Service) assists users in finding and accessing information across various library resources, and with a result of 5 (12.20%), it seems to be less effective or less used compared to other technologies. This could indicate potential usability issues or that users are not fully aware of its capabilities. The newly created MakerSpace at the Indumiso Library campus provides a collaborative workspace for making, learning, exploring and collaborating. The result of 4 (9.76%) suggests that it is underutilized or that users do not find it as beneficial compared to other services. This could highlight the need for better promotion or more targeted

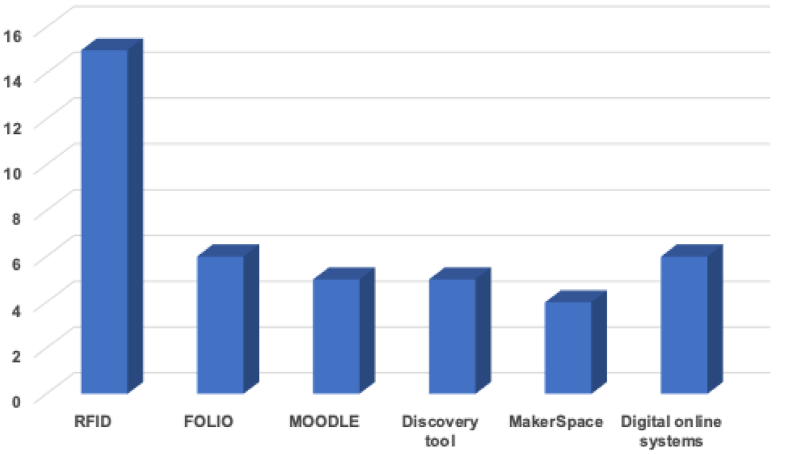

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Figure 2. 4IR technologies at the DUT library

workshops and events to increase its engagement. The digital online systems encompass a range of digital resources and services offered by the library. A result of 6 (14.63%) indicates a fair level of usage and satisfaction, suggesting that while these systems are useful, there could be improvements in user experience or additional features to enhance their effectiveness.

Assessing the alignment of 4IR infrastructure and evolving roles of librarians

The roles of academic librarians at DUT are continuously evolving to meet the demands of the 4IR and the changing landscape of higher education. As one of the interviewed participants explained, *"It is imperative for us (librarians) to keep abreast of the latest software and information technology. This cannot be done without knowledge of the latest skills and knowledge of what technology is available to enhance the output of one's job."*

The librarians have transitioned from traditional roles of managing physical collections to curating and managing vast digital resources. DUT librarians develop and maintain digital collections, including electronic books, online journals and institutional repositories. They play a vital role in ensuring the discoverability and accessibility of digital content through effective metadata management and search tools. The librarians are involved in teaching digital literacy skills to users. This is done through workshops and training sessions on digital tools, research databases and information literacy. The users are provided with guidance on the ethical use of information, including issues of copyright, plagiarism and data privacy.

Librarians are increasingly involved in supporting research activities at DUT, which includes:

(1) assisting researchers with literature searches, systematic reviews and bibliometric analysis,

(2) promoting support for research data management, including data curation, storage and sharing,

(3) assisting users navigating academic publishing, including open access and identifying predatory journals,

(4) contributing to the development of institutional policies on digital preservation, and open science initiatives,

(5) promoting the adoption and creation of OERs to reduce costs for users and to enhance access to educational materials,

(6) supporting the faculty in publishing their research in open-access journals and repositories,

(7) utilizing data analytics to customize services and resources to the needs of users.

The librarians help integrate emerging technologies into the educational experience, such as:

(1) managing and promoting the use of technology-enhanced learning spaces, such as MakerSpaces, research computer labs and the discovery tool.

(2) User data is analyzed to understand and assess user behavior, to improve services and resource allocation.

The library is closely involved with university community engagement projects and the librarians are expanding their roles to include community engagement and outreach activities through collaboration with various stakeholders.

The DUT library's ability to cope with 4IR implications

The DUT library, like many academic institutions around the world, must adapt to the challenges and opportunities presented by the 4IR. The 4IR is embodied by a fusion of technologies that blur the lines between the physical, digital and natural spheres. For any academic library to cope and survive amidst these innovations, it would need to embrace the changes and evolve with them (Moonasar and Ngoepe, 2023: p. 5).

The interviewed participants were asked about their confidence in the DUT library's capacity to manage the implications of the 4IR, and they responded as follows:

> A participant explained Staff need to be reskilled and trained for the new innovations. Management need to think creatively of ways and means of coping with 4IR and look for the relevant skills required.

> Another believed that I think the library is getting there as we have been taking initiatives to higher levels and the library has some efficient and forward-thinking staff who initiate new technologies and change.

The DUT library is fully automated and integrated with workflows for cataloging, circulation, acquisitions, periodicals, digital repositories and search tools. The library has transformed digitally by expanding access to e-resources, online journals and databases to ensure that users can access information anywhere and anytime. The library has a vast digital repository to store and provide access to research and academic outputs. The library provides regular training sessions and skills to equip library staff with the skills required to manage and use new technologies effectively. Regular training sessions and tutorials are provided to users to ensure that they can access library resources effectively. The library has a task team to regularly implement and monitor user surveys, and librarians act on the user feedback to continuously improve the services rendered. The library is striving to reduce its carbon footprint, embrace green technology and promote the sustainability of its resources.

Although there are numerous opportunities, the transition also presents challenges, with the major challenge of finance and funding for technological upgrades and the ongoing maintenance of existing technology. The challenge of closing the digital divide and ensuring that all users have access to the necessary technology and internet connectivity. The issue of protecting user's privacy and ensuring proper security measures are implemented to protect user data and ensure secure access to digital resources.

Strategic implications of aligning the library infrastructure with 4IR

This research provides a critical examination of how a University of Technology Library's infrastructure aligns with the demands of the 4IR, offering unique insights into necessary

developments in technology, policy and librarian competencies. By identifying gaps in the current technological integration and by exploring the evolving roles of librarians, strategic areas for infrastructure adaptation and skills development are highlighted. These insights are important for guiding future library policies, as they underscore the importance of creating agile, future-ready library environments that support innovative research and learning. This research can thus serve as a guideline for academic libraries to remain relevant and resilient in a rapidly changing technological environment. The following suggestions can be considered by libraries with future library policies and infrastructure adaptations:

(1) Policy guidance: the research highlights specific technological gaps and advancements needed for libraries to remain relevant, and this can be used as a guideline for future library policy formulation. Academic libraries and professional library associations can utilize these findings to set priorities in budget allocation, staffing and infrastructure upgrades.

(2) Skills development framework: by identifying the evolving librarian roles and necessary skill sets, this research can guide future training programs for librarians, ensuring that they are well-equipped with the competencies needed in a technologically driven academic environment. It can also guide policies on the continuous professional development (CPD) of library staff.

(3) Infrastructure adaptations: the insights into the 4IR platform requirements and technological integrations highlight the infrastructure planning and allow libraries the ability to make informed investments in digital and physical resources. This can be especially valuable for institutions in developing countries, assisting them to make targeted improvements within limited budget constraints.

This research offers valuable insights that can inform practical decision-making in library management and policy formulation, especially in contexts with budgetary and technological constraints.

Recommendations

There might be a need for additional training and support to help librarians better understand and utilize FOLIO to its full potential. Technical issues and improving the system features could improve and address the librarians' approval. With MOODLE, continuous enhancements and user support could further improve satisfaction and usage. And a suggestion for regular feedback from users can help identify areas for improvement. Providing more user training sessions on the discovery tool EBSCO Discovery Service (EDS) could help improve the understanding and usage of the tool. It is recommended that increasing promotion and highlighting the benefits of the discovery tool could enhance its adoption and allow users to better understand the tool. Since MakerSpace is relatively new, it needs to be widely promoted so that users can use it effectively. Librarians should be more involved with the available online platforms to understand and effectively use these systems. It seems necessary to provide comprehensive training sessions for FOLIO, EDS (the discovery tool) and MakerSpace to improve user competence and confidence.

Regular general assessments that can support academic libraries may include the active involvement of librarians with:

(1) Continuous monitoring and evaluation of systems within the library. Libraries can implement a system for the ongoing assessment of the library's technological infrastructure to ensure it remains aligned with emerging trends and technologies that continuously impact the library environment.

(2) Library management needs to consider establishing structured, ongoing training programs for new systems like the library integrated system, FOLIO, the library

discovery tool, EDS, and the MakerSpace. These training programs, in the form of hands-on workshops or periodic refresher courses, need to be tailored to address the specific skill gaps and requirements identified among the library staff.

(3) Librarians must be vigilant and regularly update the evaluation criteria to reflect on new technological advances and the changing needs of users.

(4) CPD for librarians is essential and it is important to stay updated on the latest trends impacting the sector.

(5) Establish comprehensive training programs for librarians to focus on emerging technologies, digital literacy, data management and the latest innovations.

(6) Librarians need to be encouraged to participate in workshops, conferences and courses related to the 4IR to stay current with developments within the academic environment.

(7) Conduct user needs assessments to ensure library services and technologies are designed with the end-user in mind.

(8) Engage with users, faculty and researchers to gather feedback on the usability and effectiveness of new technologies and services. The library can implement a policy for regular feedback from users regarding the usability of library systems such as the discovery tool and institutional repository. The feedback can be reviewed and used to guide updates and improve features based on user experiences.

(9) Form strategic partnerships with technology companies, vendors, academic institutions and research organizations to facilitate knowledge sharing and resource pooling. Forming partnerships with academic institutions, vendors and technology companies, allows librarians to access the latest trends and tools. This can be done by initiating pilot projects to test new technological solutions that can lead to larger-scale implementations.

(10) Library management can explore opportunities for joint ventures and collaborative projects that can enhance the library's technological capabilities.

(11) Allocate sufficient funding for the adoption and maintenance of cutting-edge technologies and innovative infrastructure within the library.

(12) Experiment with pilot projects to test the feasibility and impact of new technological initiatives prior to full-scale implementation.

(13) Implementing initiatives to ensure that all library users have equitable access to digital resources and technologies.

(14) Provide support and training for users who may need assistance in utilizing new technologies effectively.

(15) Encourage further research on the impact of 4IR technologies on library services and the evolving roles of librarians.

(16) Support studies exploring innovative uses of technology in academic libraries and their implications for teaching, learning and research.

(17) Foster a culture of innovation and flexibility among library staff to better respond to future challenges. Library management should encourage librarians to engage in ongoing research and experimentation with new technologies and motivate staff to attend 4IR-related conferences to remain current. By fostering a culture that values adaptability and continuous learning, librarians can evolve with technological innovations.

By implementing these recommendations, libraries will ensure that they are well-equipped to thrive in the era of 4IR and evolving innovative technologies and ultimately enhance their role in supporting academic excellence and innovation.

Conclusion

Although, 4IR is rapidly changing the way of work and how we interact, and with automation increasing efficiency and productivity across various sectors, human capital will still be required to co-exist alongside machines and ensure that they continue to be efficient with inputs from people. People will need to adapt and collaborate, and incorporate critical thinking skills to exist effectively alongside 4IR innovations. To succeed in this era, both people and machines will face a future built on collaboration, where people's ingenuity and creativity will be amplified by 4IR innovations. All DUT site libraries across the university have fully automated most of their core functions through the use of library management systems supported by websites, software, and other applications. Coupled with numerous ready and instant messaging reference tools the DUT library capitalizes by pushing the boundaries, although hampered by the limited infrastructural capabilities and funding provided. It is important to note that in the library a wide range of technological inclusion is used, including self-checkout/in equipment, the usage of RFID tags, and the automation of core functions to reshape information, collection access and dissemination. The 4IR is reshaping the landscape of academic librarians and the roles of librarians in the evolving digital age. Libraries are adapting to the digital age by ensuring that users can access information online by providing more digital resources, offering support for a digital scholarship within the library environment.

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