Journal of Culture and Values in Education

https://cultureandvalues.org

E-ISSN: 2590-342X

Volume: 6 Issue: 2 2023

pp. 1-17

Adoption of Fourth Industrial Revolution: Challenges in South African Higher Education Institutions

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Article Info
Received: October 10, 2022
Accepted: December 29, 2022
Published: March 2, 2023

10.46303/jcve.2023.5

How to cite
Lubinga, S., Maramura, T. C., & Masiya, T. (2023). Adoption of Fourth Industrial Revolution: Challenges in South African Higher Education Institutions. *Journal of Culture and Values in Education*, 6(2), 1-17.
https://doi.org/10.46303/jcve.2023.5

ABSTRACT

The fourth industrial revolution (4IR) adoption in South Africa in higher education institutions (HEIs) has yet to be consistent. Despite the extensive literature on the possible contributions of technology to learners' development, there is a lack of knowledge on barriers to the higher education sector's adoption of the fourth industrial revolution (4IR) to support teaching and learning. The most highly ranked universities in South Africa have somewhat embraced the 4IR, representing only a fraction of the 26 public universities in the country. The study identified factors hindering the adoption and diffusion of 4IR technologies in South Africa's HEIs. To address this knowledge gap, we relied on the diffusion of innovation theory as a guide. Using a qualitative approach, we collected data using documentary reviews and analyses of authoritative sources to conceptualise and contextualise 4IR. The findings revealed that 4IR adoption is not only about perceptions but is also influenced by material obstacles like conflicting global views on the 4IR, complexity in conceptualising 4IR, and the digital skills gap in HEIs, among other factors. To address these obstacles and realise the value of 4IR in HEIs, institutions must understand the educational scope associated with 4IR. This can be achieved by conducting more empirical research on the implications of 4IR on the education sector. To address the digital skills gap, institutions must design detailed skills plans to respond to their respective institutions' technological needs, redesign their pedagogical approaches by extending current practices to 4IR, and implement change management.

KEYWORDS

Fourth Industrial Revolution; higher education institutions; pedagogy; digital skills gap.

INTRODUCTION

The Fourth Industrial Revolution (4IR) movement is responsible for increased data volumes, advanced algorithms, artificial intelligence (AI), and automation and robotics being implemented in higher education institutions (HEIs) to improve their service quality (Rouhiainen, 2019). Because of growing demands in service quality, universities across the globe have implemented more robotic process automation, allowing them to develop more modern, sophisticated administrative operations in financial reporting, payroll, delivery of modules, and admissions (Duncan & Lundy, 2019). Highly ranked South African universities have also embraced robotic process automation and AI systems. For example, at the University of Pretoria, the University of Johannesburg, the University of Cape Town, and Witwatersrand, to name but a few (University of Pretoria, 2021; University of Johannesburg, 2020; University of Witwatersrand, 2019).

In addition to the above, a typical application domain for AI in education referred to as intelligent tutoring systems (ITS), has extended its presence in the education sector, mainly because of the COVID-19 pandemic. ITS engages students in sustained reasoning activities and interacts with them based on a deep understanding of their questions (Policy Action Network Guide, 2020). For example, Dr Maths, a project by the Council for Scientific and Industrial Research, provides South African students with mathematics tutoring support in the form of personalised real-time assistance from humans, supported by automated language clarification and topic identification (Policy Action Network Guide, 2020). Worldwide, ITS programmes include the ITS Authoring Tool for teaching information technology students how to use the Java program; SQL-Tutor teaching and explaining to students how to write relational-database queries through several lessons on the basics of writing a query; ITS for teaching advanced topics in information security; ITS for learning computer theory, and e-learning systems (Hamed & Naser, 2017). Furthermore, chatbots have been introduced as another form of AI to improve the teacher-student ratio and speed up communication. Chatbots interact directly and synchronously with students, making it possible to rely on individual intents; they include, for example, generalist bots, such as Apple’s virtual assistant; Siri; transactional bots assisting with transactions; and informational bots focusing on gathering information for users, such as Google Home (Liden & Nilios, 2020; Winkler & Söllner, 2018).

Several efforts are also being made to promote and apply robots in education. At the same time, many research groups have focused on investigating the subject and developing new tools and methods. For example, experiments and experiences with courses using robots, such as software engineering projects, hardware-based vision and genetic programming, data structures courses, AI, microcontroller programming and Fuzzy Logic, have been widely reported (Bianchi and La Neve, 2002; Dannelly, 2000; Gustafson, 1998). According to Hamed & Naser (2017), computer science students take robotics classes to learn aspects of control, mechanics, and electronics not covered in the typical computer science curriculum, while engineering students are taught computing techniques far beyond what would typically be covered in an engineering computing course (for example, issues like multi-threading, structures, and semaphores).

Research confirms that the most highly-ranked universities in South Africa have embraced the 4IR (Hlobo et al., 2022; Khoza, 2020; Mpungose, 2020; Yende, 2021). However, they represent only a fraction of the 26 universities in the country. There is a lack of knowledge regarding the drivers behind and obstacles to adopting 4IR in the higher education sector, particularly for supporting teaching and learning, despite the extensive literature on the potential contributions of technology to learners' development and rising student enrolment (Chang, 2016; Ng'Ambi et al., 2016; Oke & Fernandes, 2020. Hence, this paper examines the factors that hinder the adoption and diffusion of *4IR technologies in South Africa's HEIs.*

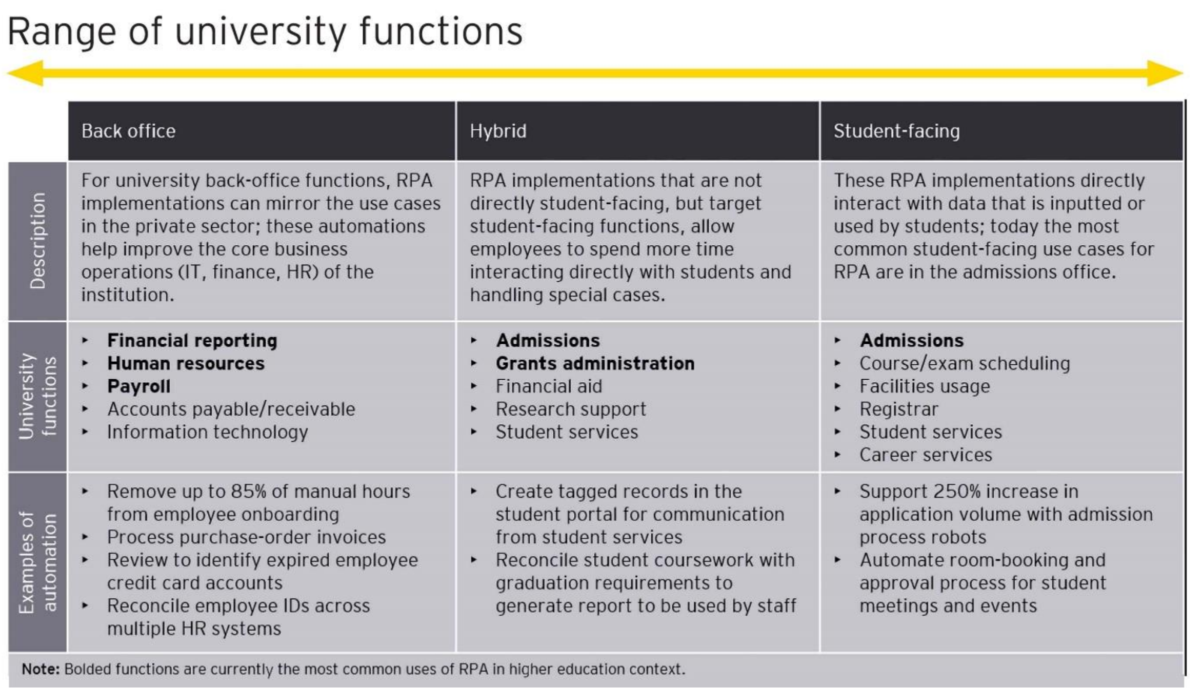
To address this knowledge gap, we relied on Rogers' 1962 diffusion of innovation theory. According to the theory, the adoption of innovations is a decision of the "full use of an innovation as the best course of action available", and rejection is a decision "not to adopt an innovation" (Rogers, 2003, p.177). Diffusion is the pattern and rate of how quickly new concepts, behaviours, or items spread within a community (Winkler & Söllner, 2018). The chain is the most prevalent type of innovation diffusion, where one source (the innovator) offers a new good or service and spreads it to other places and people (the intermediaries). It then finally arrives at the target market (the adopters). This happens in a chain because each link enables the invention to be transmitted to the next individual (Khoza, 2020) or group of individuals. To conceptualise and contextualise 4IR, we used a qualitative approach to gather data using covert research methods, such as documentary reviews and analysis of reliable sources.

This study contributes to understanding the factors hindering consistent 4IR adoption by all HEIs in South Africa. This introduction is followed by a review of the critical drivers for, and state of, 4IR adoption in South Africa's HEIs. through harnessing a theoretical framework. Next, the study describes the theoretical approach, followed by the methodology that guided this study, and then the findings. The article concludes by discussing the research implications of adopting 4IR by South African HEIs.

Overview of the Fourth Industrial Revolution in South African Education

The birth of AI goes back to the 1950s. John McCarthy gave one of the most significant definitions of artificial intelligence (AI) in 1956, stating that the field would advance on the presumption that nearly every component of learning could, in theory, be so clearly described that a computer could replicate it (Haugeland, 1985). Gordon and Ambrose (2017) state that AI can be defined as developing several analytical tools collectively attempting to exhibit intelligent behaviour. Schumacher et al. (2016) summarise the concept of 4IR as a combination of sophisticated technologies with human actors in industrial processes that call for new types of technical data and produce highly agile value chains. The Industrial Internet of Things, robotics, autonomous vehicles, biotechnology, cyber-physical systems, fifth-generation wireless, and quantum computing are all included in the 4IR (Schwab, 2016; Sutherland, 2020). In addition, AI and machine learning are frequently mentioned in the same academic context because machine learning is an approach to AI that can be used for supervised and unsupervised profiling, such as predicting a student's likelihood of failing a course or identifying themes in written texts (Zawacki-Richter et al., 2019).

Greater data quantities, sophisticated algorithms, artificial intelligence (AI), automation, and robotics are all results of the 4IR movement. In addition, because of COVID-19, many institutions have attempted to implement 4IR to improve their service quality. Furthermore, with growing service-quality demands, universities are implementing more robotic process automation, allowing them to develop more modern, sophisticated administrative operations. An exciting example of robotic process automation in universities is illustrated in Figure 1 below.



Range of university functions

	Back office	Hybrid	Student-facing
Description	For university back-office functions, RPA implementations can mirror the use cases in the private sector; these automations help improve the core business operations (IT, finance, HR) of the institution.	RPA implementations that are not directly student-facing, but target student-facing functions, allow employees to spend more time interacting directly with students and handling special cases.	These RPA implementations directly interact with data that is inputted or used by students; today the most common student-facing use cases for RPA are in the admissions office.
University functions	▸ **Financial reporting** ▸ **Human resources** ▸ **Payroll** ▸ Accounts payable/receivable ▸ Information technology	▸ **Admissions** ▸ **Grants administration** ▸ Financial aid ▸ Research support ▸ Student services	▸ **Admissions** ▸ Course/exam scheduling ▸ Facilities usage ▸ Registrar ▸ Student services ▸ Career services
Examples of automation	▸ Remove up to 85% of manual hours from employee onboarding ▸ Process purchase-order invoices ▸ Review to identify expired employee credit card accounts ▸ Reconcile employee IDs across multiple HR systems	▸ Create tagged records in the student portal for communication from student services ▸ Reconcile student coursework with graduation requirements to generate report to be used by staff	▸ Support 250% increase in application volume with admission process robots ▸ Automate room-booking and approval process for student meetings and events

Note: Bolded functions are currently the most common uses of RPA in higher education context.

Figure 1: *Robotic process automation in universities* (Adopted from Duncan and Lundy, 2019)

Similarly, most South African universities have embraced automation and realised the benefits of quality, speed and agility that these services provide. For example, at the University of Pretoria, users can now order services under various portfolios, such as business systems, to apply for data services and change passwords (University of Pretoria, 2021). The University of Pretoria (2021) further indicates that there are communication and collaboration systems through emails and mobile sources; support infrastructure systems, such as off-site laptop support, and teaching and learning management systems for classroom technology and automated marking. In addition to the above, institutions are also taking the leading role in championing and integrating 4IR initiatives. For instance, as a catalyst for its Strategy for Global Excellence and Stature, the University of Johannesburg founded the Institute for Intelligent Systems (University of Johannesburg, 2020). Academic development, strategic research, and business development are the three key elements through which this institute functions. The institute's academic focus is on creating multidisciplinary taught and online programs for postgraduate certification and ongoing professional development to develop capacity in machine learning, artificial intelligence, data science, and the Internet of Things (University of Johannesburg, 2020). The University of Johannesburg, the University of Witwatersrand, and the University of Fort Hare are among the founding members of the 4IRSA alliance, which aims to hasten the creation of a cogent, inclusive national response to the 4IR. Other founding members include the Department of Communications and Digital Technologies, Deloitte, Huawei, and Vodacom (University of Witwatersrand, 2019).

Concerning curricula, South African universities that provide traditional commerce degrees have added 4IR-related programs as electives or core modules to their curricula. Students pursuing a Bachelor of Commerce degree at the University of Cape Town, for instance, can specialise in "traditional" fields like Accounting, Actuarial Science, Economics, and Management, while those pursuing a Bachelor of Business Sciences degree can do so in 12 areas that deal specifically with analytical techniques relevant to advancements in the 4IR (Coetzee et al., 2021). A Bachelor of Commerce in Mathematical Statistics with a concentration in data science is given at Stellenbosch University, where students must collect, store, convert, and visually portray data (Coetzee et al., 2021). Last but not least, there have been significant changes at the University of Pretoria owing to the addition of modules on design thinking, business innovation, business analytics (covering subjects like data mining, big data, and data stream analysis), and responsible leadership (Coetzee et al., 2021).

In 2019, in pursuit of the University of Pretoria’s focus on evolving in line with the 4IR, the Department of Library Services employed the first known client-service robot in Africa (called Libby) at any university library (University of Pretoria, 2019). Furthermore, in 2021 the University of Johannesburg purchased a smart, agile, mobile robot (SPOT), which was a first for academic institutions in South Africa and the African continent at large. SPOT can traverse terrain with previously unheard-of mobility while carrying a hefty weight (University of Johannesburg, 2021).

Theoretical Approach

The reasons for and obstacles to adopting the 4IR within the higher education sector, particularly for supporting teaching and learning, are not well understood, despite the extensive literature on the potential contributions of technology to learners' development and rising student enrolment (Chang, 2016; Ng'Ambi et al., 2016; Oke & Fernandes, 2020). According to research, adopting a new good, service, or concept does not happen quickly and differs depending on the social structure (Rogers, 2003; Zhang et al., 2015). In addition, early adopters of innovation have traits that set them apart from slow adopters (Rogers, 2003). The drivers of adoption have not been examined in the South African university sector. This study used the diffusion of innovation theory to understand the motivations for and barriers to South African universities adopting the 4IR. One of the most prevalent ideas for examining information technology adoption and comprehending how information technology breakthroughs move both inside and between societies is the diffusion of innovation theory (Sahin, 2006). With timelines potentially extending over lengthy periods, it is frequently used to describe how and why new concepts and practices get embraced. This theory holds that adoption means "using an innovation fully as the best course of action available", while rejection means "not adopting an innovation" (Rogers, 2003). Furthermore, diffusion is defined as "how an innovation is communicated over time within a social system through certain channels" (Rogers, 2003). In the theory, innovation, communication channels, time, and social systems are the four critical components of innovation diffusion (Sahin, 2006; Zhang et al., 2015). Innovation refers to an idea, process or technology unfamiliar to individuals within a particular area or social system. The term "communication channels" refers to the channels, including interpersonal and mass media, via which people learn about innovations and judge their value. Five user-perceived qualities — relative benefit, compatibility, complexity, trialability, and observability — are included in the characteristics of an innovation (Sahin, 2006; Zhang et al., 2015).

The term "relative advantage" describes the extent to which a user adopts an innovation and perceives the advantages of or advancements made to the current technology. The degree to which an innovation fits nicely into the current social and technological environment is measured by its compatibility. The degree to which an innovation is deemed difficult to understand and apply is measured by its complexity. The capacity to test an idea without making a significant financial or time commitment is known as trialability. Lastly, observability refers to how potential users may see the advantages of an innovation. Only when the results are perceived as advantageous is the innovation adopted. In addition, only when the outcomes are valuable will the innovation be adopted (Sachin, 2006; Zhang et al., 2015). This suggests that it is crucial to understand how university leaders perceive the benefits of 4IR, and their adoption strategies are the first point of reference. According to Rogers (2003), the theory groups individuals into five types of adopters in a social system and the categories are based on attitudes to innovation; these categories are:

- **Innovators** generally make up 2.5% of a social system's population and they are the ones who introduce new theories, concepts, and technology.
- **Early adopters** are constrained by the social system's restrictions. Early adopters, therefore, are more likely to assume leadership positions in the social system; other members rely on them for guidance and for details about the invention (Rogers, 2003).
- The **early majority** represent 34% of the population and are distinguished by their early adoption of advancements. They are neither the first nor the last to adopt innovation, but they do so on purpose. As a result, their decision to innovate typically takes longer than that of innovators and early adopters (Rogers, 2003).
- The **late majority** are similar to the early majority. They make up 34% of all social system members who wait adoption until most of their peers have adopted the innovation. They are sceptical of innovation and its results but are susceptible to peer pressure and economic need (Rogers, 2003).

- The **laggards** comprise up to 16% of the total population. Laggards have a traditional viewpoint compared to the late majority and are more sceptical of innovations and change agents. Their interpersonal networks are primarily made up of other social system members who fall into the same category since they are the most localised "group of the social system". In addition, they are not in leadership positions (Rogers, 2003).

While these groupings inform the research, the study's goal was not to classify the adoption, or lack of adoption by the 26 universities into these categories. Instead, the focus was to understand the motivations for and challenges to adopting the 4IR. It does appear, however, that the percentage of the 26 universities that have somewhat adopted 4IR is consistent with the theory's categorisation of innovators. Furthermore, the theory points to the need to understand the complex factors affecting adoption and the role of leaders.

METHODOLOGY

This paper employed a qualitative approach in the interpretivist tradition. To understand various thoughts, opinions, or experiences, qualitative research in the context of the current study refers to gathering and analysing non-numerical data (such as text, video, or audio) (Pathak, Jena & Kalra, 2013). To conceptualise and contextualise the 4IR in HEIs, this research derived its arguments from secondary evidence, which included documentary and conceptual examination of reliable sources. A qualitative technique was chosen because it enabled the study to concentrate on the meaning and to apply diverse methods to reflect various facets of the problem. Data were gathered from publications in journals. All sources were selected based on the general principles of handling sources, namely authenticity, credibility, representativeness and meaning (Mogalakwe, 2006). The researchers ensured that all sources included were genuine and coherent and represented the totality of the relevant documents written by leading authors on agile governance. To select the most appropriate sources on the 4IR, the researchers searched from Google Scholar using the terms '4IR' and 'higher education institutions', resulting in 15 000 hits. The search was further refined, focusing on the works on South African institutions. Once the sources had been chosen according to relevance, a general hermeneutical reading process was conducted (George, 2020; Wessels, 2021) to understand the motivations for and challenges to adopting the 4IR in South African HEIs. The rationale behind this choice is that general hermeneutics aims to understand texts holistically rather than to understand words or sentences individually. In addition, the process is interested in disruptive semantic aspects of meaning, which are theoretical units of meaning-holding elements utilised to express word meaning and are relevant to the process (Mogalakwe, 2006).

To further make sense of the content, thematic analysis was used. Thematic analysis is a qualitative data analysis process involving the construction of themes and subthemes identified as repetitive patterns in a data set (Bryman, 2016). It is derived from extensive and scrupulous reading of transcripts and notes of data and then organising and examining to make a case

(Bryman, 2016). For all the selected documents, the study followed the six phases of thematic analysis, namely familiarisation, coding, searching for themes, reviewing themes, defining themes, and naming themes. In the familiarisation step, the study ensured a thorough reading of the selected sources and, using ATLAS. ti software, the study identified repetitive patterns and created codes. From the codes, the researchers created themes by grouping codes to map key or high-order patterns of the critical drivers and challenges hindering 4IR adoption in South Africa's HEIs. Lastly, names were given to the themes to provide a map for the findings and discussion section.

ANALYSIS AND FINDINGS

Using ATLAS.ti software, the barriers abstracted from the data were itemised and coded according to 23 emerging themes. The 23 codes were then placed into four barrier categories that typified challenges faced by South African HEIs in adopting 4IR technologies. The categories were grouped based on their direct influence on the adoption of the 4IR in higher education; globally conflicting views on the 4IR; complexity in the concept of 4IR; the digital skills gap in HEIs, and incompatibility with institutional, cultural norms, values and standards. See Figure 2 below.

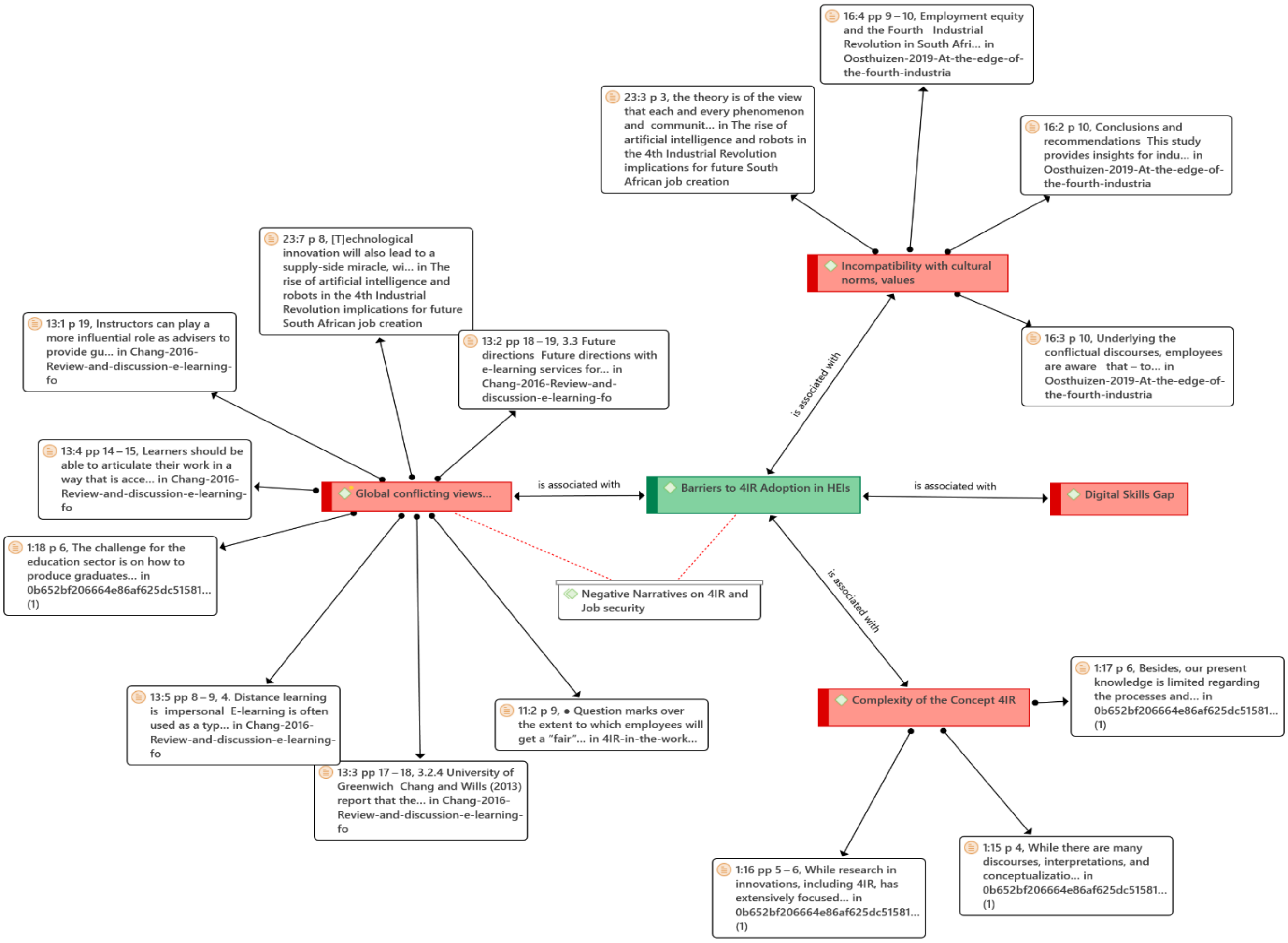


Figure 2: *Network Diagram depicting the four barrier categories that typified the challenges South African HEIs face in adopting 4IR technologies* (Generated from Atlas.ti).

Conflicting Global Views on the Fourth Industrial Revolution

The Fourth Industrial Revolution, with its associated automation, robotisation and AI, is transforming the workplace in various ways. One can assert that two views primarily dominate this discussion (Dahlin, 2019), namely the optimistic and the pessimistic. The optimistic view focuses on the future and is characterised by ease, immortality, gratification, and dominance, all associated with the narrative that intelligent machines affect society in a transformative, positive manner (The Royal Society, 2019). This view is supported by the narratives of the rise of the gig economy and the growth of "alternative work arrangements" (Malinga, 2021); the rise of precarious employment; the unbundling of skills and tasks, where digital platforms allow work to be divided into piecework where once good, middle-class jobs that are routine and repetitive are being squeezed out by automation; and the unbundling of skills and tasks (Deckha, 2020).

When AI is applied to education, the best outcome will be from combining human capabilities and AI strengths (Rouhiainen, 2019). Using the 4IR, primarily through automation, can lead to increased production of goods and services, allowing employees to spend less time at work and more at home with their families. In addition, using robotics and connected devices has the potential to significantly improve workplace safety because robots can perform some risky tasks (IBA Global Employment Institute, 2018). New technology can also make workplaces safe by keeping people out of dangerous environments. For instance, a deep-learning algorithm can be used to monitor worker accidents or chemical leaks in real time by detecting human behaviour patterns through security cameras. Oke and Fernandes (2020, p. 22) assert that computer-based learning, particularly e-learning, offers the chance to allow teaching and training anywhere and anytime, hence lowering operating expenses and minimising logistical challenges sometimes connected with face-to-face classroom instruction.

Contrary to the above, the pessimistic view, also referred to as the displacement view, suggests that employees who perform routine tasks are at a higher risk of being adversely affected, while those who engage in cognitively complex tasks will remain immune to an extent (The Royal Society, 2019; Dahlin, 2019). For instance, an employee working on an assembly line is more likely to be replaced by a robot than a marketing executive creating emotionally compelling advertisements (Dahlin, 2019). An extreme version of this view states that with the continuous improvement of AI, machines will render humans utterly unnecessary within the workplace (Dahlin, 2019). What was thought to be science fiction is becoming a reality in specific environments (Dahlin, 2019). This view is confirmed by the literature indicating that AI already undertakes tasks such as detecting medical conditions, engaging in conversation, and driving (Dahlin, 2019). According to Brougham and Haar (2018), the rise of AI could create an environment of mass unemployment. The authors have also indicated that one-third of today's jobs could be lost by 2025. This is due, in part, to the significant improvement of intelligent systems and inexpensive autonomous units that could potentially outperform humans in various conceptual tasks (Brougham & Haar, 2018).

According to Ocaña-Fernández et al. (2020), many citizens in the so-called 'world village' are considered to be in an unprivileged position regarding AI technologies and are unaware of the possible effects. Unlike in the other industrial revolutions, in the 4IR machines can learn and teach themselves and require fewer interventions, creating a sense of uncertainty about the need for humans and potential employment. In addition, according to Arntz et al. (2016), it was estimated that 9% of all individuals in the United States of America had a job with great potential for automation, with present technology enabling the automation of at least 70% of performed operations. In contrast, workers with higher educational levels and income were less likely to be at risk of losing their jobs as opposed to the low-skilled with low income (Hirschi, 2018). Furthermore, Zhang and Dafoe (2019) submit that more Americans believe that advanced artificial intelligence would harm people than those who believe it will benefit them. While 22% believe the technology will be "on balance bad," 12% believe it will be "very awful," possibly resulting in the extinction of humans. However, according to the McKinsey Global Institute (2018), 21% believe it will be "on balance good", and 5% believe it would be "very good" (2018). This is also noted by The Royal Society (2019) in the population of the United Kingdom, where the overall findings revealed that the majority of beliefs relating to the impact of AI elicited significant anxiety; in particular, obsolescence (the belief that AI might mean humans become excessively reliant on machines and replace the need for humans in jobs) scored the highest.

Owing to the factors diverse beliefs mentioned above, divisive discourses appear to hinder employees' creativity and ideas for the transition to the 4IR. Who can blame them though? Forecasts indicate a drop in the demand for individuals with fundamental cognitive abilities, such as primary data entry and processing (McKinsey Global Institute, 2018). The institute adds that it is anticipated that this demand will decrease by 15%, going from 18% to 14% of total hours worked. Despite a 14% decline in demand, physical and manual skills, including general equipment operation, will still make up the majority of workforce skills in many nations in 2030, accounting for 25% of all hours worked (Bughin, Seong, Manyika, Chui, & Joshi, 2018). In addition, and according to Acemoglu and Restrepo (2017), between 1990 and 2007, the number of industrial robots per thousand workers in a local area decreased by 0.18% to 0.34% points, and wages decreased by 0.25% to 0.50%. Thus, given the unemployment rate in South Africa, much of the workforce's excitement around AI can quickly be replaced by fear of job losses, which hinders the adoption of the 4IR.

Complexity

According to the literature (Oke & Fernandes, 2020; Zhang & Dafoe, 2019), academics perceive the 4IR as a complex concept that is difficult to use or adopt. Regarding the complexity of the concept, though the concept has existed for a while now, there has yet to be an agreed-upon definition of what it entails in the teaching and learning space. Not only is the concept contested, but it also keeps evolving (Oke, 2020). For example, Sutherland (2020) submits that 4IR is:

> […] not the result of careful historical analysis, rather, it is a flag to rally and a rhetorical device for those trying to create economic and commercial futures, hoping to ride waves of Schumpeterian economic disruption caused by 'extreme automation and extreme connectivity (p. 233).

The procedures and methods HEIs should use to guarantee that the 4IR capabilities are enhanced in teaching practices have yet to be understood. Our analysis shows that, despite the potential benefits of technology for learners' growth through collaborative learning, little is known about the drivers of adoption and diffusion of the 4IR in the educational sector and how they affect the teaching and learning process (Chang, 2016; Ng'Ambi et al., 2016; Oke & Fernandes, 2020). In addition, none of the 50 most innovative corporations in the world is an academic institution, and no African organisation was found on the list (Warschauer, 2007).

Incompatibility

In addition to the already stated perceptions is the challenge of incompatibility, which refers to the degree to which innovation is seen as inconsistent with the existing values, needs and functioning of HEIs**.** Although there is diffusion and acceptance of technology in other sectors, the effectiveness and efficacy of the technology, particularly online teaching and learning, have not yet been proven. Instead, there is evidence of underlying challenges to intellectual integrity, such as contract cheating because of platforms or tutors helping students with assessments and other exam solutions (Lubinga et al., 2022). In addition, the nature of teaching and learning has not been effectively changed by digital technologies, particularly in higher education. For instance, Ng'Ambi et al. (2016) found that despite the use of technology in the classroom, teaching and learning, notably in South Africa, remained essentially the same. The limited use of technology to support teaching and learning has focused on digitisation as opposed to digitalisation. All the 26 institutions have not embraced teaching in innovative lecture halls and the Internet of Things has been inconsistently applied across institutions; big data analytics to track student performance is unheard of, as data capturing is still done manually, and augmented and virtual realities are a far reach for historically disadvantaged universities.

For instance, several HEIs rely on hybrid cloud infrastructure with computing platforms on private clouds for their enterprise architecture. Alternatively, business and educational applications gradually migrate to public clouds (Aldowah et al., 2017). Furthermore, many technological breakthroughs and tools are not owned by the education sector, indicating that academic institutions have not regulated the development or use of these. The above highlights the incompatibility of the 4IR with the values, beliefs and expectations of students in the African context. In some institutions, student engagement, emotional intelligence, and communication are soft critical skills for all graduates. So, the perception that the introduction of the 4IR will erode these skills is unmistakable. Moreover, curricular and pedagogical approaches have been stagnant for many years and are still designed according to traditional ways, albeit with new technology (Menon & Castrillon, 2019). Institutions still use a paper-and-glass method, where documents are only uploaded for students to access at their own pace, in spite of online instruction (Oke & Fernandes, 2020). In addition, the current pedagogical approaches exclude current practices relating to the 4IR (Oke & Fernandes, 2020).

In addition, for the Afrocentric fanatics, the 4IR goes against the Afrocentric theory, which promotes the view that every phenomenon and community of Africa can never be interpreted and comprehensively understood by scholars who reside outside Africa. This makes it challenging to adopt and support the perception that the 4IR is incompatible with African values (Rapanyane & Sethole, 2020). Furthermore, South Africa's 11 official languages present a unique challenge to engage with various speakers. Thus, the process involved in deploying such intelligent agents requires an interdisciplinary approach between management, software developers and computational linguists. Implementing any AI technology, such as chatbots, requires an infrastructure with unique components and processes dedicated to its intended industry sector and end-users, which is not visible in many HEIs (Oke & Fernandes, 2020).

Whether public or private, the discourse in South African organisations is dominated by post-apartheid categories relating to race, gender, and employment equity that reinforce the historical split with the rest of the world, causing the adoption of any new initiative to take a back seat (Oosthuizen & Mayer, 2019). This leaves many employees and institutional management concerned about how the policies enacted to correct the past injustices will impact their progress as opposed to looking at any new technological advancements. Furthermore, universities are responsible for creating social justice and equity to try and reverse the effects of the past (Badat, 2010), and thus the focus on 4IR may tend to take a back seat, as focus is placed on addressing social issues.

RECOMMENDATIONS

From the above discussion, one can assert that the views on 4IR advancement in the workplace are twofold. The first view is that the advancement of the 4IR in the workplace can benefit workers, and the second is that 4IR advancement could be to employees' detriment as many could lose their jobs. The fact that neither view has been thoroughly proven poses a challenge to adopting the 4IR in the workplace – and the higher education environment is not any different. In addition, based on the literature, three broad factors hinder the adoption of the 4IR in higher education, namely incompatibility, the digital divide, and complexity. However, since the 4IR is here to stay and, to overcome these challenges, HEIs can adopt the following solutions:

- Despite the excitement surrounding the 4IR and given the uncertainty of job security as prior depicted, the higher education sector must understand the specific educational scope and risks associated with the 4IR. Only this way will it realise the actual value of the 4IR. This should be done by conducting more empirical research on the implications of the 4IR on the higher education sector.

- Because of the demands of the 4IR and the changing landscape, institutions must create comprehensive skill plans to document and address the technology needs of their staff members.
- The adoption of the 4IR is constrained by the status of the infrastructure and present thinking about the functions of education, particularly the teaching and learning processes. As a result, it is imperative that educational institutions, particularly HEIs, revamp their pedagogical strategies by expanding their current methods to incorporate the 4IR.
- Investing in technology is one thing, but adjusting a curriculum and pedagogy is quite another. Teaching and applying innovation are not simple lesson-taught skill-acquired processes. Equally, adoption requires learning various skills, accepting novel approaches, and coping with continual social change. This is to keep up with the required skills and deliver the skills necessary to produce a graduate who can navigate the 4IR. In addition, HEIs must use change management to educate staff members on how the 4IR may increase productivity and cut down on time spent on tedious tasks.

CONCLUSION

Digital skills are required to ensure that personnel stay up to date with technological change, which is vital in the 4IR because the 4IR is powered by AI. Like this, the 4IR represents a significant change in the kinds of talents needed to complete particular activities. Skills associated with emerging technologies such as AI, the Internet of Things, blockchain, automation, data science and programming were found to be the scarcest in almost all South African sectors. Not all 26 South African HEIs have claimed their space in the 21st century, as some are still behind in several indicators essential for a successful digital revolution. This was because of a gap in the country's digital and technological skills and because of low levels of higher education achievement.

REFERENCES

Arntz, M., Gregory, T., & Zierahn, U. (2016). *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. OECD Social, Employment and Migration Working Papers*, No. 189, OECD Publishing, Paris. https://doi.org/10.1787/5jlz9h56dvq7-en

Aldowah, H., Rehman, S. U., Ghazal, S., & Umar, I. N. (2017). Internet of Things in higher education: A study on future learning. *Journal of Physics Conference Series*, *892*(1), 012017. https://doi.org/10.1088/1742-6596/892/1/012017

Badat, S. (2010). *The challenges of transformation in higher education and training institutions in South Africa*. Development Bank of Southern Africa, 8. https://www.ru.ac.za/media/rhodesuniversity/content/vc/documents/The_Challenges_of_Transformation_in_Higher_Eduaction_and_Training_Institutions_in_South_Africa.pdf

Bianchi, R. A. C., & La Neve, A. (2002). *Studying electrical and computer engineering through the construction of robotic teams and systems* [Paper presentation]. International Conference on Engineering Education, Manchester, Eng., United Kingdom.

Brougham, D., & Haar, J. (2018). Smart Technology, Artificial Intelligence, Robotics, and Algorithms (STARA): Employees' perceptions of our future workplace. *Journal of Management & Organization, 24*(2), 239-257. https://doi.org/10.1017/jmo.2016.55

Bryman, A. (2016). *Social Research Methods* (5th ed.). Oxford University Press.

Bughin, j., Seong, J., Manyika, J., Chui, M., & Joshi, R. (2018). Notes from the AI frontier: Modeling the impact of AI on the world economy. McKinsey Global Institute. https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world-economy

Chang, V. (2016). Review and discussion: E-learning for academia and industry. *International Journal of Information Management, 36*(3), 476–485. https://doi.org/10.1016/j.ijinfomgt.2015.12.007

Coetzee, J., Neneh, B., Stemmet, K., Lamprecht, J., Motsitsi, C., & Sereeco, W. (2021). South African universities in a time of increasing disruption. *South African Journal of Economic and Management Sciences, 24*(1), 1-12. https://doi.org/10.4102/sajems.v24i1.3739

Dahlin, E. (2019). Are Robots Stealing Our Jobs? *Socius*, 5. https://doi.org/10.1177/2378023119846249

Dannelly, R.S. (2000). Use of a mobile robot in a data structures course. *Journal of Computing in Small Colleges*, *15*(3), 85–90.

Deckha, N. (2020). The Fourth Industrial Revolution, human skills, and online learning: Notes from the higher educational experiences of police officers. *International Journal on Innovations in Online Education, 4*(4), 1-17. https://doi.org/10.1615/IntJInnovOnlineEdu.2020030824

Duncan, B., & Lundy, K. (2019). *How universities are using robotic process automation.* EY. https://www.ey.com/en_us/government-public-sector/how-universities-are-using-robotic-process-automation

George, T. (2020, December 9). *Hermeneutics*. Stanford Encyclopedia of Philosophy Archive. https://plato.stanford.edu/archives/win2021/entries/hermeneutics/

Gustafson, D. (1998). *Using robotics to teach software engineering* [Paper presentation]. Frontiers in Education Conference, Tempe, AZ, United States.

Gordon, D. L., & Ambrose, R. L. (2017). The Ethics of Artificial intelligence. *Internet Encyclopedia of Philosophy*. https://iep.utm.edu/ethics-of-artificial-intelligence/

Haugeland, J. (1985). *Artificial Intelligence: The Very Idea*. MIT Press.

Hamed, M. A., & Nasser, S. S. A. (2017). An intelligent tutoring system for teaching the 7 characteristics of living things. *International Journal of Advanced Research and Development, 2(*1), 31-35. https://core.ac.uk/download/pdf/131210576.pdf

Hirschi, A. (2018). The Fourth Industrial Revolution: Issues and implications for career research and practice. *The Career Development Quarterly, 66*(3), 192–204. https://doi.org/10.1002/cdq.12142

Hlobo, M., Moloi, T., & Mhlanga, D. (2022). *The Fourth Industrial Revolution in South Africa's private higher education institutions and further education and training colleges*. Conference proceedings of the Ireland International Conference on Education (IICE-2021), Ireland, 2021. *Infonomics Society, 37*. https://www.researchgate.net/publication/357899877_The_Fourth_Industrial_Revolution_in_South_Africa%27s_Private_Higher_Education_Institutions_and_Further_Education_and_Training_Colleges

IBA Global Employment Institute. (2018). *Artificial Intelligence and Robotics and Their Impact on the Workplace.* IBA Global Employment Institute. https://cms.law/en/deu/news-information/artificial-intelligence-and-robotics-and-their-impact-on-the-workplace

Khoza, S. B. (2020). Academics' "why" of knowledge-building for the Fourth Industrial Revolution and COVID-19 era. *International Journal of Higher Education*, *6*(6), 247-258 https://doi.org/10.5430/ijhe.v9n6p247

Liden, A., & Nilios, K. (2020). *Perceived benefits and limitations of chatbots in higher education* [Bachelors dissertation, University of Linnaeus]. https://www.diva-portal.org/smash/get/diva2:1442044/FULLTEXT01.pdf

Lubinga, N. S., Ramnarain, J., & Tonkin, L. (in press). Quandaries of Contract Cheating in South African Higher Education Institutions: The Way Forward.

Malinga, S. (2021). *Tech skills gap endangers digital economy, 4IR progress*. https://www.itweb.co.za/content/G98YdqLY14JvX2PD

McKinsey Global Institute. (2018). Notes from the AI frontier: Modeling the impact of AI on the world economy. https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world-economy

Menon, K., & Castrillon, G. (2019, Apr 15). Universities have 'pivotal role' to play in Fourth Industrial Revolution. *Daily Maverick*. https://www.dailymaverick.co.za/article/2019-04-15-universities-have-pivotal-role-to-play-in-fourth-industrial-revolution/

Mpungose, C.B. (2020). Beyond limits: Lecturers' reflections on Moodle uptake in South African universities. *Education and Information Technologies* 25, 5033–5052. https://doi.org/10.1007/s10639-020-10190-8

Mogalakwe, M. (2006). The Use of Documentary Research Methods in Social Research. *African Sociological Review*, *10*(1), 221-230. https://www.researchgate.net/publication/267994948_The_Use_of_Documentary_Research_Methods_in_Social_Research

Ng'Ambi, D., Brown, C., Bozalek, V., Gachago, D., & Woos, D. (2016). Technology enhanced teaching and learning in South African higher education – A rearview of a 20-year journey. *British Journal of Educational Technology, 47*(5), 843–858. https://doi.org/10.1111/bjet.12485Ocaña-Fernandez, Y., Valenzuela-Fernandez, L., & Garro-Aburto, L. (2019). Artificial Intelligence and its Implications in Higher Education. *Propósitos y Representaciones*, 7(2), 536-568. http://dx.doi.org/10.20511/pyr2019.v7n2.274

Oke, A., & Fernandes, F. A. P. (2020). Innovations in teaching and learning: Exploring the perceptions of the education sector on the 4th Industrial Revolution (4IR). *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(2), Article 31. https://doi.org/10.3390/joitmc6020031

Oosthuizen, R. M., & Mayer, C. -H., (2019). At the edge of the Fourth Industrial Revolution: Employees' perceptions of employment equity from a CIBART perspective. *South African Journal of Industrial Psychology*, *45*. https://doi.org/10.4102/sajip.v45i0.1695

Pathak, V., Jena, B., & Kalra, S. (2013). Qualitative research. *Perspectives in clinical research*, *4*(3), 192. https://doi.org/10.4103/2229-3485.115389

Policy Action Network Guide. (2020). *AI and data in education: Policy considerations for South Africa*. Policy Action. https://policyaction.org.za/sites/default/files/PAN_TopicalGuide_AIData3_Education_Elec.pdf

Rapanyane, M. B., & Sethole, F. R. (2020). The rise of artificial intelligence and robots in the 4th Industrial Revolution: Implications for future South African job creation. *Contemporary Social Science*, *15*(4), 489–501. https://doi.org/10.1080/21582041.2020.1806346

Rogers, E.M. (2003). *Diffusion of innovations* (3rd ed.). Free Press. https://teddykw2.files.wordpress.com/2012/07/everett-m-rogers-diffusion-of-innovations.pdf

Rouhiainen, L. (2019). How AI and Data could personalize higher education. Harvard Business Review Education. https://hbsp.harvard.edu/product/H056XO-PDF-ENG

Sahin, I. (2006). Detailed Review of Rogers' Diffusion of Innovations Theory and Educational Technology-Related Studies Based on Rogers' Theory. *Turkish Online Journal of Educational Technology, 5*, 14-23.

Sutherland, E. (2020). The Fourth Industrial Revolution – The case of South Africa. *Politikon 47* (2), 233–252. https://doi.org/10.1080/02589346.2019.1696003

Schwab, K. (2016). The Fourth Industrial Revolution. *World Economic Forum, Cologny/Germany.* https://law.unimelb.edu.au/__data/assets/pdf_file/0005/3385454/Schwab-The_Fourth_Industrial_Revolution_Klaus_S.pdf

Schumacher, A., Erol, S., Sihn, W. A. (2016). Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises. *Procedia CIRP, 52,* 161–166. https://doi.org/10.1016/j.procir.2016.07.040

The Royal Society. (2019). *Portrayals and perceptions of AI and why they matter.* The Royal Society. https://royalsociety.org/-/media/policy/projects/ai-narratives/AI-narratives-workshop-findings.pdf

University of Johannesburg. (2021). *UJ the first university in South Africa to secure AI robot 'dog' – SPOT*. University of Johannesburg. https://www.uj.ac.za/news/uj-the-first-university-in-south-africa-to-secure-ai-robot-dog-spot/

University of Pretoria. (2019). *UP Libraries steps into future as it 'employs' robot to help students*. University of Pretoria. https://www.up.ac.za/news/post_2814363-up-libraries-steps-into-future-as-it-employs-robot-to-help-students

University of Witwatersrand. (2019). *Embrace 4IR to address poverty, inequality and unemployment – Ramaphosa*. University of Witwatersrand. https://www.wits.ac.za/future/stories/embrace-4ir-to-address-poverty-inequality-and-unemployment---ramaphosa.html

Warschauer, M. (2007). *The paradoxical future of digital learning*. *Learning Inquiry 1*, 41–49. https://doi.org/10.1007/s11519-007-0001-5

Winkler, R., & Söllner, M. (2018). *Unleashing the potential of chatbots in education: A state-of-the-art analysis* [Paper presentation]. Academy of Management Annual Meeting (AOM), Chicago, United States. https://www.researchgate.net/publication/326281264_Unleashing_the_Potential_of_Chatbots_in_Education_A_State-Of-The-Art_Analysis

Wessels, J. S. (2021). A policy instrument to relieve child poverty: The case of the child support grant in South Africa. In J. S. Wessels, T. Potgieter, & T. Naidoo (Eds.), *Public administration challenges – cases from Africa* (pp. 51-78). Juta.

Yende, J. S. (2021). A transition towards the Fourth Industrial Revolution (4IR) in the South African education sector: A perspective from rural-based higher education. *African Journal of Development Studies*, *11*(2). https://journals.co.za/doi/pdf/10.31920/2634-3649/2021/v11n2a3

Zhang, B., & Dafoe, A. (2019). *Artificial intelligence: American attitudes and trends*. http://dx.doi.org/10.2139/ssrn.3312874 or https://ssrn.com/abstract=3312874

Zawacki-Richter, O., Marín, V.I., Bond, M. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(39), 1-27. https://doi.org/10.1186/s41239-019-0171-0