



Fourth Industrial Revolution Tools to Enhance the Growth and Development of Teaching and Learning in Higher Education Institutions: A Systematic Literature Review in South Africa

Lilian Ifunanya Nwosu^{*a} Makuena Clementina Bereng^b, Tlotlo Segotso^a & Ngozi Blessing Enebe^b

* Corresponding author

Email: 23012064@nwu.ac.za

a. Faculty of Economics and Management Sciences, North West University, Mafikeng, South Africa


b. School of Professional Studies in Education, North West University, Mafikeng, South Africa

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ABSTRACT

The Fourth Industrial Revolution (4IR) has been the subject of discussion, and in most cases, it has been seen as a threat to jobs and conventional methods of performing certain activities. As a result, concerns over the preparation of the South African educational systems for the 4IR have been raised. Many industries still lack an advanced understanding of the 4IR, but the concept is already gaining ground in various economic areas. Thus, academics, business professionals, and legislators are paying closer attention to 4IR. The researchers were inspired to examine how the 4IR techniques were applied in South African Higher Education Institutions (HEIs) to advance the growth and development of teaching and learning by this noticeable knowledge gap. To investigate how 4IR technologies improve the growth and development of teaching and learning in South African HEIs, this study used a systematic literature review (SLR) methodology. A search procedure, research keywords, inclusion and exclusion criteria, and quality assessments of chosen literature were used in conjunction with the SLR approach. Twenty-one documents were retained after selecting them according to their theme and outline objectives. This study found that some South African HEIs have successfully adopted 4IR virtual and contact instruction technologies. The research further found that academics and support staff utilized various 4IR tools. This is done through a virtual or hybrid classroom, artificial intelligence, and the Internet of Things (IoT), with different devices to send students messages, schedule Zoom classes, and provide feedback and educational resources. However, the study presented recommendations that academics can use to ensure that the 4IR is effectively integrated to support the expansion and improvement of teaching and learning in HEIs. Future research directions were suggested, and the study came to the conclusion that South Africa could change the direction of the management of the education sector by implementing various 4IR tools in HEIs.

KEYWORDS

Fourth industrial revolution; higher education institutions; growth; development; teaching and learning; academics

INTRODUCTION AND BACKGROUND

With the use of the SLR, this study seeks to identify how the 4IR technologies can be used to enhance the growth and development of teaching and learning in HEIs. According to Schwab (2016), the 4IR expands on the Third Industrial Revolution by fusing several technologies from the digital, physical, and biological spheres. The steam engine was developed during the First Industrial Revolution, which preceded the discovery of the internal combustion engine during the Second Industrial Revolution. The First Industrial Revolution started in the 1780s with steam power, increasing human productivity (Erboz, 2017). The Second Industrial Revolution began in the 1870s with the introduction of electrical energy and mass production. The emergence of “cyber-physical systems,” which relate to whole new capacities for humans and robots, might be characterized as the 4IR. However, the 4IR represents new ways technology becomes ingrained inside society and our bodies. These new capabilities depend on the infrastructure and technologies of the Third Industrial Revolution. It integrates numerous physical, digital, and biological technologies (McGinnis, 2018).

The first three industrial revolutions laid the groundwork for the 4IR, which is not a novel idea. This has led to the debate about the 4IR being viewed as a threat to jobs and ordinary ways of doing things (Davis, 2016). To that effect, concerns about the South African education systems' readiness for 4IR have been questioned, particularly with the emergence of the Coronavirus disease (COVID-19) in March 2020. According to Mhlanga and Moloji (2020), the 4IR infrastructure difficulty caused the lockdown to affect most public schools in South Africa, especially those in townships and rural areas. Furthermore, no feasible interventions were set up to cater for such circumstances; thus, universities and traditional schools that did not have 4IR instruments had to close down at the commencement of the lockdown required by COVID-19. According to Mhlanga and Moloji (2020), this is anticipated to be a typical occurrence across the African continent due to infrastructure issues, broadband availability, and data costs. According to Butler-Adam (2018), 4IR has many ramifications for many facets of life. As a result, it presents opportunities and difficulties for the educational system.

Despite the many challenges, the 4IR has presented many exciting opportunities to HEIs. Any education plan for the 4IR must build on the Third Industrial Revolution's development of in-person instruction and diverse asynchronous educational resources (Penprase, 2018). The education industry could completely transform to provide solutions to new difficulties due to using numerous 4IR components (Kayembe, 2019). Rübmann et al., (2015) state that having adequate knowledge of the various 4IR components—including autonomous robots, simulation, horizontal and vertical system integration, the Internet of Things (IoT), cyber security, cloud, additive manufacturing, augmented reality, and big data—is the first step in understanding the roles and relevance of the 4IR in the growth and development of teaching and learning in HEIs. Effective teaching and learning will be facilitated in HEIs by integrating these 4IR components. Professors and students from various disciplines should also learn about the elements necessary to implement the 4IR successfully.

Ramukumba (2019) based his observations on this assumption and stressed the importance of a revamped curriculum that covers new topics and courses such as coding, data analysis, and robotics to prepare students for opportunities in 4IR. Furthermore, the 4IR is also characterized using Information and Communication Technology (ICT), which calls for HEIs to be competent in ICT. In order to improve the growth and development of teaching and learning in HEIs, the current study attempts to identify the 4IR instruments that can be applied. The study is expected to highlight possibilities and gaps that might be filled to enhance teaching and learning in HEIs throughout the 4IR era and offer insight into difficulties that must be overcome.

Problem and objectives

Many industries still lack an advanced understanding of the 4IR, but the concept is already gaining ground in various economic areas. As a result, academics, business professionals, and legislators are paying closer attention to 4IR (Lee et al., 2018; Lubinga et al. 2023). HEIs thus play a crucial part in influencing the societal changes required to adapt to 4IR for better growth and development. This is because higher education was previously created to address the demands of earlier industrial revolutions prioritizing mass production using electricity (Gleason, 2018). Therefore, it is essential that HEIs bridge the gap between the first three industrial revolutions and the current 4IR by implementing the usage of 4IR tools to teach successfully.

The utilisation of ICT is another aspect of 4IR. Technology has only been used in a didactic approach to teaching and learning, wherein a personal computer and the availability of electronic teaching resources were used to facilitate instruction (Brown, 2015). Lee et al., (2018) emphasize that digital technology goes beyond using computers and e-materials to support 4IR. This suggests that educators should be able to integrate ICT into educational activities and through curriculum development to produce students who are competent in ICT. In agreement, Hennessy et al., (2010) assert that over the years, it has become evident that if ICT is used appropriately, it may be a valuable tool for assisting instruction. Mbodila et al., (2013) observe that lecturers could develop strategies to promote deep learning and change learning into a learner-centred approach through ICT implementation in education. Despite technological advancements, the South African education sector has slowly embraced technology as a teaching and learning aid (Mhlanga & Moloi, 2020).

Educators struggle to integrate ICT efficiently into education due to inadequate resources and a lack of training (Ramorola, 2013). Professional competencies must change as 4IR does to address the opportunities and difficulties of the digital transition (Lee et al., 2018). Education in the 4IR era calls for teachers and students who have received ICT training and are equipped with those skills, as digital transformation is essential to the expansion and improvement of an institution.

The 4IR is characterized by a much more pervasive mobile internet, more affordable, smaller, and powerful AI machine-learning-enabled sensors (Schwab, 2016). In essence, apart from ICT, educators in HEIs should be able to integrate various strategies to impart knowledge to their students and train them to be competent in using technological platforms such as social

media in the 4IR era. Furthermore, tremendous changes are occurring in a world increasingly reliant on technology, including smart devices, quantum computing, and driverless cars (Manyika, 2017). As such, people need to be trained to stay abreast with the new changes, especially in HEIs, where graduates are prepared for the future world of work.

This study's major goal is to determine which 4IR tools are utilized to advance the growth and development of teaching and learning in HEIs in South Africa, owing to the dire need for quality, relevant, and lifelong education deemed suitable by the 4IR components through SLR.

MATERIAL AND METHODS

Research approach

The SLR provides updated information on a research focus area and clarifies future research paths (Kunisch, 2018). It guided the researchers in identifying the essential gaps and questions in the existing literature. The SLR is also identified as the method that assists researchers in answering the research question by creating transparent scientific evidence based on the current literature (Lame, 2019). The SLR process for this study employed the preferred reporting items for systematic review and meta-analysis (PRISMA) within the context of 4IR techniques to enhance the growth and development of teaching and learning in South African HEIs. This approach was also thought to be pertinent for the current study since it enabled the researchers to present a thorough analysis of the body of information regarding the usage of 4IR as a teaching and learning resource in higher education settings. Furthermore, the SLR is considered the most practical research method in terms of transparency compared to other traditional research methods (Aarseth et al., 2017).

Search strategy, inclusion and exclusion criteria

The literature used in this study was sourced from three databases, namely Google, Sabinet, and EBSCOhost. The literature includes studies on the 4IR technologies, teaching and learning, and South African HEIs. The following search terms were used in the literature search: "4IR growth and development in HEIs", "4IR and teaching and learning", and "4IR tools in HEIs". The search was sorted by language (English) and document type (article, book chapter, and conference paper). No time limit was applied. These search engines were found to be dominant in the publication of academic research work that focuses on developing and enhancing 4IR in HEIs. Initially, the search produced 85 documents. After the search process was completed, duplicated documents (article, book chapter and conference paper) were eliminated. A total of 31 duplicated documents were eliminated, resulting in 54 documents.

To ensure the inclusion of relevant articles relating to the 4IR technology themes, teaching and learning, and South African HEIs, the researchers read the abstracts of all 54 papers and categorized them as either included or excluded from this study. Thirty-three of the 54 research papers were considered unrelated and irrelevant to the current study; as a result, they were excluded. This stage was conducted by two authors and further verified by two authors to

reinforce the assessment, reducing the number of documents and avoiding excluding relevant and non-related articles. A summary of the search results is presented in Table 1 below.

Table 1: *Summary of search results*

Search results	Google	Sabinet	EBSCOhost	Total no. of publications	Total excluded from the current study	Total included in the current study
Journals	36	10	11	57	45	12
Conferences	7	3	3	13	10	3
Book chapters	8	5	2	15	6	9
Total	51	18	16	85	64	21

Methodological quality assessment

The methodological quality of the 21 documents retained was assessed using a six-question checklist developed by Pitchforth et al., (2017). The aim was to determine if these documents meet this study's inclusion or exclusion criteria. A component approaches following PRISMA was used when applying the checklist. The checklist assesses six study criteria using a 'yes' or 'no' score. Three authors independently conducted the quality assessment and further verified by one author to reinforce the assessment. A consensus was reached amongst the four authors regarding the 21 documents using a checklist developed by Pitchforth et al. (2017), as shown in Table 2.

Table 2: *Methodological quality assessment criteria*

Quality assessment questions	Consensus
Q1 Are the objectives of the study clearly identified?	Yes
Q2 Is the context of the study clearly stated?	Yes
Q3 Do the research methods support the aims of the study?	Yes
Q4 Does the study have a comprehensive description of the instruments/scales employed?	Yes
Q5 Is there a clear statement of the findings?	Yes
Q6 Are the limitations of the study discussed extensively and explicitly?	Yes

Results

A total of 21 documents relating to the 4IR growth and development tools in HEIs were analyzed through content analysis and following the guidelines presented by Jarvis et al., (2003) and Aarseth et al., (2017). The authors read each article, and the inclusion and exclusion criteria were applied on the basis that only articles relating to the 4IR tools in HEIs were relevant. In contrast, the studies that did not meet the inclusion criteria were deemed irrelevant to the current study and were thus excluded. Table 1 below shows the details of all the articles found

during the search process. They are grouped into the following columns: “Inclusion in the current study” and “Exclusion from the current study”.

Articles related to the 4IR tools to enhance the growth and development of teaching and learning in HEIs were sourced using the SLR approach. Each article was further categorized according to the authors, title, theme, weaknesses, and strengths to enable the researchers to identify the key themes that address the current study’s research objectives. The themes used to accomplish the research objectives for this current study were identified using the SLR approach. Consequently, the researcher further reviewed and discussed these themes in more detail. The details of this category are presented in Table 2 below.

Table 3: Categorisation of reviewed studies

Author	Title	Challenges of 4IR tools in the teaching and learning in HEIs	Opportunities of 4IR tools in the teaching and learning in HEIs
Brown, J.P. (2015)	The complexity of using digital technology and how function is taught and learned.	Despite the potential of digital technologies to improve teaching and learning, it is unattainable due to the lack of available technology tools.	According to the researcher, using 4IR will enable teachers and students to solve and manage complex tasks.
Ganiyu, I.O., Oyedele, O.O. & Derera, E. (2021)	Disruptions of the Fourth Industrial Revolution: Implication for work-life balance strategies	The issue of inequality may increase due to the technological revolution, and global labour markets may be disrupted.	4IR is thought to raise the level of living worldwide, improving people’s quality of life worldwide. Globally, people’s living standards are alleged to have improved due to 4IR disruptions.
Gleason, N.W. (2018)	Higher education in the era of the Fourth Industrial Revolution	The difficulty level and employment volatility would increase because of the new frameworks developed in response to the changes.	With a curriculum that fosters both technical competence and a keen understanding of ethical duty toward the human condition, these new forms of 4IR education will equip students and faculty for leadership roles in a world of quickly accelerating change.
Hariharasudan, A. & Kot, S. (2018)	A scoping review on Digital English and Education 4.0 for Industry 4.0	The researcher mentioned language barriers, a lack of digital culture, and a lack of expertise and training as obstacles to a successful deployment of 4IR.	All facets of our life are affected by Industry 4.0 and its significance.
Lee, M., Yun, J.J., Pyka, A., Won, D., Kodama, F., Schiuma, G., Park, H., Jeon, J., Park, K., Jung, K. & Yan, M.R. (2018)	How to respond to the Fourth Industrial Revolution, or the second information technology revolution? Dynamic new combinations between technology and market	Different authors have different ways of defining 4IR.	Following this conversation, individuals in academia or business will be able to create their own 4IR concepts, which will open up prospects for them to conduct 4IR-related research or develop a variety of creative commercial agendas.
Mbodila, M., Jones, T. & Muhandji, K. (2013)	Integration of ICT in education: Key challenges	The use of ICT in teaching and learning focuses more on technological possibilities than the needs of education has been identified as a significant challenge.	However, the use of ICT in education enables students to be independent, think critically, and be problem solvers. It also promotes deep learning.
Mhlanga, D. & Moloi, T. (2020)	COVID-19 and the digital transformation of education: What are we learning on 4IR in South Africa?	These authors pointed out that during the educational transformation, due to the COVID-19 outbreak, students (mostly those from disadvantaged backgrounds) could not fully benefit from online teaching and learning due to a shortage of data or a lack of signal connection.	These findings show that South Africa typically has several areas of expertise that might potentially push the educational industry into the 4IR and increase access.
Ramorola, M. Z. (2013)	Challenge of effective technology integration into teaching and learning	The results showed that the primary obstacles to the successful adoption of technology at the school level included a lack of a technology policy, inadequate technology resources, a shortage of	Technology integration needs careful preparation, patience, commitment, and resources.

		teachers skilled in technology integration, and maintenance and technical issues. Due to limited technology, a lack of teachers with the necessary skills and the unavailability of technology policies makes it difficult to adopt 4IR tools in teaching and learning. Additionally, the researcher also mentioned that students had difficulty accessing the online sessions due to a lack of internet. The teachers also had limited to attain relevant training.	
Roy, A. (2020)	The Fourth Industrial Revolution	This paper argues that although the introduction of AI has many advantages, not all organizations adopting it reap its benefits. The author further adds that suppliers endure more pain than consumers.	According to the researcher, the disruptions illuminated by the introduction of AI will positively and negatively impact organizations. However, on the other hand, AI seems to impact consumers positively.
Penprase, (2018)	B.E. The Fourth Industrial Revolution and higher education	HEIs still need to focus on changing their curricula to incorporate technological systems in their teaching and learning, notwithstanding the benefits of 4IR technology in teaching and learning.	The students and the faculty will benefit from the 4IR education in a way that will equip them with the necessary skills to take on leadership roles in a rapidly changing world.
McGinnis, (2018)	D. What Is The Fourth Industrial Revolution?	The industry's consequences similarly impact the workforce. Again, there will be job losses or significant job changes.	The author concluded that we do not know what the future holds. As a result, we should prepare our students for the future by allowing them to explore these technological systems.

DISCUSSION OF RESULTS

This paper provides insight into the 4IR tools for advancing the growth and development of instruction in HEIs whilst identifying themes through the SLR of scientific papers (as categorised in Table 2). The themes identified address the challenges and opportunities in the 4IR tools in advancing teaching and learning in HEIs, and ways to combat these challenges. These themes will address the study's main research objective.

The 4IR keys for advancing growth and development of instruction in higher education

Improving teaching and learning in higher education using the 4IR is a growing concern for most world economies. Therefore, it becomes imperative that the education sector and, most importantly, HEIs, embrace this trend in digital technology to keep abreast with the 21st century's demands. Furthermore, digital technology's progress aims to impose a uniform style of conducting business throughout society and higher education (Yende, 2021). Therefore, it has been anticipated that e-learning will replace traditional classroom instruction in higher education (Yende & Yende, 2019).

This makes it clear that as digital technology develops in higher education, physical instruction will eventually give way to digital pedagogy. This study discovered that examinations are written utilising technological advancements due to the growing digitalization of teaching and learning in HEIs (Yende & Yende, 2019). HEIs have seen a more significant increase in digitalized testing. Students utilize internet-connected computers to keep up with school activities daily (Yende & Yende, 2019). Hybrid learning is also a critical 4IR tool that fosters

effective teaching and learning (Ganiyu et al., 2021). Using these tools promotes the growth and development of teaching and learning at HEIs.

Challenges of the 4IR tools in teaching and learning in HEIs

Higher education experiences challenges in teaching and learning in line with using 4IR tools. Despite its known merits in higher education, there is a need to revisit the curriculum to align contents to technological trends. This is consistent with Penprase's (2018) assertion that, despite the benefits of 4IR technology for teaching and learning, HEIs must still make changes to their curricula to include technology systems in their teaching and learning. Although e-learning is a 4IR tool, it is viewed as a cutting-edge global system essential to higher education. However, it is crucial to note that e-learning may jeopardize the viability of higher education at institutions lacking in technology, such as rural colleges (Butler-Adam, 2018). The official policy for marginalized institutions is one of the core components of the 4IR in higher education (Winanti et al., 2019). For a transition towards the 4IR to successfully adopt digital technology, pertinent organizations, such as the Department of Higher Education and Training (among other governmental organizations), should provide financing to advance and upgrade the infrastructure of rural-based institutions (Butler-Adam, 2018; Xing & Marwala, 2006).

Furthermore, the lack of digital culture, training, and knowledge impacts the advancement of higher education teaching and learning (Hariharasudan & Kot, 2018). To address the escalating rate of change, complexity, and instability of employment, new frameworks should be developed per career and technical education (CTE) (Gleason, 2018). In HEIs, the advantages of technological possibilities are emphasized more than the gains and impacts of education. The use of ICT in teaching and learning focuses more on technical capabilities instead of education needs, which has been identified as a challenge (Mbodila et al., 2013). Ramorola's (2013) findings revealed more difficulties in engaging 4IR tools in educational institutions. The authors emphasized that the primary obstacles preventing the efficient integration of technology in educational institutions were a lack of technological policy, inadequate technology equipment, a lack of competent employees in technology integration and maintenance, and technical issues.

Opportunities of the 4IR tools in instructional activities in HEIs

Opportunities in the educational system, particularly in higher education, were made possible by incorporating 4IR instruments in teaching and learning. Better technological means of knowledge transmission were made possible by the 4IR tools. However, integrating technology demands preparation, adequate time, commitment, and suitable money (Ramorola, 2013). The 4IR, according to Schwab (2016), is a vital instrument for enhancing higher education globally and fostering the development of critical skills, including e-learning and innovation, information and media technology, and life and job skills. These abilities increase a person's ability to compete in the workplace and business. Additionally, the world and the markets that require certain vital digital abilities have fundamentally transformed due to the advancement of digital technology (Gibbs, 2017).

Butler-Adam (2018) asserts that many European schools and American and Australian HEIs have seen success in their educational systems due to embracing digital transformation. Serdyukov (2017) contends that nations that have adopted the 4IR in their higher education system are in a better position to have a thriving economy in the future. Furthermore, the advantages of integrating 4IR tools into teaching and learning in HEIs will benefit the students and the teaching staff. Finally, Penprase (2018) asserts that the students and the faculty will benefit from the 4IR education in a way that will equip them with the necessary skills to take on leadership roles in a rapidly changing world.

Combating challenges of the 4IR in advancing instruction in HEIs

According to a study by Serdyukov (2017), several attempts have been made in South Africa to align curricula with the necessary 4IR capabilities since the technological redress concentrates on curricula in higher education. To provide students with the required skills supported by digital technology, industry and the educational sector must collaborate to establish the future of digital technology in higher education (Yende, 2021). In combating 4IR challenges faced in higher education, the curriculum should clearly emphasize digital technology, such as AI, automation, and internet technology, to ensure learners understand what 4IR is and its application in today's world.

The expectations and behaviors of the culture of teaching and learning in the classroom, as articulated through digital assets in higher education, will be radically altered by the 4IR (Butler-Adam, 2018). The analytical, creative, critical, problem-solving, and critical-thinking abilities are part of digital technology, and necessary to exploit digital technology opportunities, which can only be imparted to learners when lecturers are knowledgeable about them (Yende, 2012). Therefore, this points to the fact that transmitters of learning ought to be technologically compliant to bring about the reality of 4IR in the classrooms. To prepare students for opportunities in the 4IR, HEI instructors must learn and demonstrate the necessary tools and abilities.

CONCLUSIONS AND RECOMMENDATIONS

This study aimed to examine how the 4IR can be used to improve the growth and development of teaching and learning in South African HEIs. This study used the SLR methodology because it offers a deeper knowledge of the phenomenon and its effects on teaching and learning in HEIs; this method was pertinent to this study.

Academics could incorporate various 4IR in teaching and learning, such as writing tests using technological innovations, digitalized testing, internet-connected computers, and hybrid learning for growth and development in HEIs. It became apparent from the literature reviewed that 4IR tools impact teaching and learning. Without these tools, students could be ill-equipped for work, and teaching and learning may be affected in the long run. As such, these tools foster the growth and development of teaching and learning in HEIs. This study, therefore,

recommends that training be provided for academics who struggle to utilize these tools as this will prepare them for the challenges ahead and future services.

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