

# Preparing African Higher Education Institutions for the Fourth Industrial Revolution: The Role of Artificial Intelligence (AI) in Curriculum Development

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**Abstract.** The fourth industrial revolution is reshaping economies worldwide, necessitating the integration of Artificial Intelligence (AI) and other advanced technologies into various sectors, including higher education. In Africa, higher education institutions face the pressing challenge of aligning their curricula with recent technological trends to remain competitive and relevant in the global knowledge economy. This paper assesses the role of Artificial Intelligence (AI) in building curriculum as a fundamental strategy for preparing higher education institutions in Africa to meet the standards of the Fourth Industrial Revolution (4IR). The study highlights how Artificial Intelligence tools can reshape curriculum design, promote personalised education experiences, and improve learning and teaching methodologies.

Furthermore, the study examines the challenges that higher education institutions face when adopting Artificial Intelligence technologies. These challenges include, but are not limited to, inadequacy of skilled personnel, limited infrastructure, and funding constraints. Ultimately, incorporating artificial intelligence into curriculum development is fundamental to promoting innovation, improving academic outcomes, and positioning African higher education institutions to better thrive in the 4IR era.

**Keywords:** Artificial Intelligence; Fourth Industrial Revolution; Teaching; Learning; Curriculum Development; Institutions; Higher Education; Students.

## INTRODUCTION

Business leaders, particularly at events like the World Economic Forum (WEF), have extensively deliberated on the concept of the Fourth Industrial Revolution (4IR). Recent reports examine how the Fourth Industrial Revolution will impact key areas, such as work and education, and emphasise the need for accelerating workforce re-skilling [1]. A comprehensive analysis of the Fourth Industrial Revolution has been published in book form, detailing key emerging technologies believed to be driving the Fourth Industrial Revolution, as well as the societal implications of these changes [2]. The term Fourth Industrial Revolution (4IR) originates from early studies of technological evolution, where the First Industrial Revolution emerged from the use of water and steam power to create a more efficient and organised manufacturing process. Historians com-

monly describe the First Industrial Revolution as the application of steam engines in Cornwall's mining industry and emphasise how steam power played a crucial role in immensely expanding the scale of manufacturing. Steam power has been vividly described as "the hub through which the spokes of coal, iron and cotton were linked" [3]. The term 'Industrial Revolution' itself originated from the author's [4] work, 'Lecture on the Industrial Revolution'. In the author's view [4], the transformation into an industrial revolution occurred not only through the growth of power and mechanical production but also through its connection with a "political culture which was receptive to change" [5], which involved changes in financial structures alongside other social advancements. The author [6] stated that the Industrial Revolution was not just a speedup of economic development but more so a

catalyst for growth, driven by and through social and economic transformation.

The Fourth Industrial Revolution (4IR) relies on several technologies that connect the physical and digital worlds, fostering the development of intelligent and autonomous industries. These technologies include augmented reality (AR), the Internet of Things, Autonomous Robots, Cybersecurity, Big Data and Analytics, Cloud Computing, Additive Manufacturing, Simulation and Horizontal and Vertical System Integration. While many modern industries, businesses and supply chains are already utilising some of these technologies, it is the integration of all of them that allows the Fourth Industrial Revolution (4IR) to reach its full potential [7].

The Fourth Industrial Revolution introduced remarkable technological progress, revolutionising industries and greatly influencing the global economy [8]. These changes and adjustments also impact higher education, as institutions are increasingly being notified to modify their curricula, organisational design, and teaching methods to prepare students for the rapidly evolving needs of the Fourth Industrial Revolution [9]. The higher education system is currently undergoing significant changes in response to the Fourth Industrial Revolution, driven by the inclusion of new technologies such as artificial intelligence (AI), machine learning, and big data analysis, which are reshaping teaching and learning in institutions of higher education [10]. Such technologies provide avenues for individualised instruction, data-influenced decision-making mechanisms and adaptive tests [11].

Additionally, the Fourth Industrial Revolution is generating demand for increasingly interdisciplinary programs that combine technical competencies, flexibility, analytical thinking, and imagination [12]. With the changing industries and new occupations being created, tertiary institutions are redesigning their course offerings and curricula to ensure that graduates are equipped for success in the digital age [13]. This paper aims to evaluate the role of AI in curriculum development in preparing African higher education institutions for the Fourth Industrial Revolution.

*The Current State of African Higher Education Institutions.* Africa, a continent consisting of fifty-four countries, has 2,389 universities as of 2023 [14]. Compared to global standards, Africa is the least advanced region in terms of higher education institutions and student enrollment [15].

Although some African nations have well-developed academic systems, the majority have only a small number of higher education institutions and have not yet established the diverse post-secondary systems necessary for the information age [15]. The best universities in Africa span 19 countries, from Uganda in the east to Nigeria in the west, Morocco in the north to South Africa at the southernmost tip of the continent. Overall, Egypt and Algeria are the most represented African countries in the ranking, with 35 and 26 universities, respectively. While South African universities account for half of the top ten, 14 are described in the overall ranking. Egypt, Ghana, Nigeria, Uganda, and South Africa all have universities ranked among the world's top 1000. The ranking utilises 18 characteristics to evaluate university performance, including teaching, research environment, research quality, global outlook, and industry engagement [16]. Meanwhile, countries such as Somalia, Angola, and the Democratic Republic of the Congo have lost university-level institutions due to political instability. They are now working to rebuild their higher education sectors [17].

One of the challenges facing African higher education institutions is access to education. The demand for access to higher education is increasing in nearly all African countries, putting pressure on the resources of educational institutions. As enrollment numbers grow, institutions that were initially designed to accommodate fewer students continue to admit more, yet financial resources have not kept pace with this surge. In several nations, resources have decreased due to factors such as currency devaluation, inflation, political and economic instability, and structural adjustment programs, which have further weakened the financial stability of these institutions and systems [17]. Another challenge for higher education institutions on the continent is funding. At the start of the twenty-first century, the primary challenge for all African higher education systems is a severe financial crisis. While academic institutions worldwide, including those in wealthy industrialised nations, face financial difficulties, the scale of these challenges is more pronounced in Africa than anywhere else. Higher Education in Africa is a multi-billion-dollar industry, valued at around \$4 to \$5 billion. Egypt, with the largest student population on the continent, allocates approximately US\$6 billion to its higher education system, which accounts for about 1.7% of the country's GDP [18]. Nigeria, with an esti-

mated budget of approximately \$ 2.16 billion, accounts for about 7.3% of the total budget for 2025 [19]. South Africa, Libya, Algeria and Tunisia also contribute significantly to the remaining expenses compared to other African nations. For a continent with over 1 billion people, this level of spending is strikingly low. The total annual expenditure on higher Education across Africa is far smaller than the endowments of some of the wealthiest universities in the United States. The budget of individual universities in many industrialised countries surpasses the entire national budget for higher education in several African nations. These comparisons highlight the significant financial gap between higher education institutions in Africa and those in industrialised countries [16]. Other challenges facing African higher education institutions include governance, excessive non-academic staff, private higher education, management issues in universities, gender research, addressing the brain drain, capacity-building issues, academic freedom, student activism, and the language of instruction [16].

*The Role of AI in Transforming Higher Education.* The rise of Artificial Intelligence (AI) has had a profound effect on higher education, acting as a major driver of change. This shift brings both new opportunities and challenges that require thoughtful attention. The integration of AI in higher education has the potential to alter how students learn radically, instructors teach, and how institutions operate. Implementing AI has its complications and challenges that need to be addressed for it to realise its potential [20]. The use of AI in tertiary education is skyrocketing, resulting in a shift not only in what and when students learn but also in who delivers lessons. The leading roles AI plays in reshaping tertiary education are indicated below:

*Personalised Learning:* This form of learning is becoming increasingly prevalent as AI-based platforms adapt teaching content to meet the needs and interests of each learner. Real-time support from intelligent tutoring systems maximises the educational outcome through personalised assessments and constructive feedback [21]. It is increasingly necessary for higher education institutions to utilise predictive analytics to identify students who may face academic difficulties. The timely deployment of interventions and solutions for improving student retention and success can then occur. Furthermore, chatbots and virtual assistants are being increasingly incorporated into educational settings, as they

efficiently manage routine tasks and provide easily accessible information and services to staff and students [22].

*Curriculum Design:* Artificial Intelligence is impacting curriculum design by analysing trends in the labour market and identifying emerging fields, enabling educational institutions to design programs that are as current and relevant as possible. AI has significantly enhanced research processes by analysing data, thereby increasing efficiency in uncovering valuable insights. It is also crucial for detecting plagiarism and maintaining integrity by comparing student work against massive collections of academic and online resources [23].

*Administrative Efficiency:* Augmented and virtual reality technologies are making immersive learning a reality, while AI-based resource allocation and scheduling are enhancing administrative efficiency. AI integration is also proving fruitful in career counselling and accessibility tools [24].

*Artificial Intelligence in Curriculum Development for the Fourth Industrial Revolution.* Research in diverse educational fields corroborates the influence of Artificial Intelligence on curriculum development. AI-driven intelligent tutoring systems play a crucial role in providing personalised instruction tailored to each learner's unique style [25]. According to the authors [26], the accuracy of an automated grading system, a type of artificial intelligence in education, is similar to that of human graders, thereby fostering both time efficiency and consistency in grading. The analytical abilities of AI also include detecting 'at-risk' students by evaluating data, allowing for timely and circumspect interventions [27]. Predictive analytics help educators envision probable risks of dropout or course failure, allowing for preemptive actions to be taken [28]. Artificial Intelligence integration, a key factor in personalised learning, increases student engagement while also improving general learning outcomes. Artificial Intelligence-powered systems measure students' weaknesses, strengths and learning predictions to create personalised learning pathways [29]. Authors [30, 31] describe an extensive array of Artificial Intelligence applications in educational management. They include personalised learning, where learning paths are customised by Artificial Intelligence based on each student's peculiar characteristics; intelligent tutoring systems which deliver instantaneous feedback and personalised learning experiences; student perfor-

mance prediction through Artificial Intelligence systems that analyse several data to enable hands-on interventions; automated grading for multiple-choice and short-answer questions, which saves teachers' time; learning analytics which allow educators to find patterns and trends in students' data; Artificial Intelligence-powered chatbots and virtual assistants which deliver immediate responses to common questions; campus safety with Artificial Intelligence-driven surveillance systems; admissions and recruitment where Artificial Intelligence evaluates applicant's data; automation of financial aid and student services as well as AI's role in curriculum development by analysing job market tendencies and identifying evolving skill requirements.

In African higher education, the use of Artificial Intelligence offers boundless promises for improving various elements of curriculum delivery. Artificial intelligence helps streamline lecture planning and preparation, which are essential for effective curriculum delivery, by automating routine tasks such as lesson planning, scheduling, attendance tracking, grading, and record maintenance [32]. This automation not only reduces the administrative load for teaching staff but also enables educators to devote more time to improving the quality of teaching. Additionally, Artificial Intelligence tools can generate automatic notices, report cards, and communications with parents, creating more efficient avenues of communication. Preparation of construction materials for efficient lecture delivery is a function usually performed by academic staff. However, artificial intelligence plays a part in this context through its clever content generation, which takes the form of videos, teaching clips, and e-textbooks.

Authors [32] highlighted the Artificial Intelligence capabilities in assisting with personalised learning, which is a worldwide movement in alignment with the future of education. Artificial Intelligence mechanisms are capable of creating personalised teaching environments based on specific educational strategies and objectives, which include basics such as AR/VR lessons and online materials. Additionally, AI-based monitoring and evaluation tools, powered by machine-learning algorithms, help identify areas for curriculum upgrade, ensuring content caters to diverse learning styles. The adaptive approach enhances the general merit of course materials and allows teachers to refine their teaching methods.

Preparing teaching materials for classes is a significant task for teaching staff in African tertiary education. Careful planning and organisation help accomplish the task, and Artificial Intelligence has become an essential aid in the process [32]. Furthermore, Artificial Intelligence-based monitoring and evaluation tools are necessary for refining and adjusting content to accommodate different learning styles and paces, as well as identifying areas for improvement and augmentation in the curriculum.

Artificial Intelligence plays a substantial role in enhancing lecture presentations, a crucial element in curriculum implementation in higher education institutions. It has improved the value of lecture materials and methodologies, aligning them with the capacities and necessities of colleges and universities [33].

Artificial intelligence helps in developing an artificial intelligence framework within the universal education system, promoting students' overall interest, sustainable development, and global governance. By assessing students' learning styles and abilities, Artificial Intelligence enables the creation of personalised learning experiences, allowing educators to adapt teaching methods, curricula, and resources to suit students' unique needs [34]. Artificial intelligence can analyse extensive datasets of students' information, such as trends in behaviour and assessment scores, to identify areas where they might be facing difficulties, paving the way for targeted interventions [35]. Furthermore, AI-driven grading software streamlines the grading of students' scripts, utilising machine learning to effectively simulate the human grading process [30]. These tools integrate effortlessly into cloud-based or virtual platforms, providing fast and precise grading, which is especially valuable when managing large volumes of paper.

Lecturers can use AI to assign online tasks to students, promoting engagement with the curriculum. Smith highlights how AI helps lecturers and teachers manage assignments, streamlining the process of issuing and collecting online tasks [31]. Additionally, AI plays a key role in preparing and releasing students, which is vital for effective curriculum execution. The technology supports administrators and educators in analysing large datasets, including students' resource distribution, performance and attendance [36]. AI-driven systems identify patterns and trends, providing valuable insights that inform the deci-

sion-making process; this enables administrators to create data-driven strategies to enhance students' outcomes, optimise resource allocation and assess programs.

AI assistance simplifies the crucial task of selecting suitable teaching methods for lectures. Widely implemented in colleges and universities, intelligent teaching support systems gather and analyse data, align with students' learning styles and enhance teacher-student communication. This technology facilitates lesson planning, material collection, assessments, teaching evaluations and online quizzes. By easing daily workloads, it also introduced innovative teaching strategies that nurture students' creativity and social skills [36].

AI is transforming the way students' progress is monitored in higher education. Authors [37] emphasise that intelligent teaching platforms enable teachers to track students' learning progress remotely, offer personalised resources and provide real-time guidance. The platforms foster interactive learning by using data analysis to tailor instruction to individual student needs. Furthermore, AI algorithms assess various factors, such as academic performance and attendance, to help identify students at risk of falling behind and facilitate timely intervention [38].

Overall, the integration of AI into African higher education enhances lecture planning, provides personalised instructional resources, improves lecture delivery, streamlines assessment processes and accelerates grading - Ultimately strengthening the effectiveness of curriculum implementation.

*Technological Infrastructure and AI Adoption Challenges.* People often regard Africa as one of the least technologically advanced regions in the world, particularly in terms of income, education, school enrollment ratios, infrastructure, and, most significantly, information and communication technologies [39]. Presently, only a handful of countries among the sixty-two on the continent are recognised for their technological capabilities. Nevertheless, even in these nations, access to essential tools that drive innovation is connected mainly in a few select cities [40]. Despite accounting for a significant share of the global population, only around 7% of the world's internet users resided in Africa as of 2013 [41]. The exclusion of most African countries from the information society highlights the severity of the digital divide across the continent [42]. This digital divide in Africa mainly reflects the continent's

lower number of computers, fixed telephone lines, internet access, and limited infrastructure to support mobile devices and broadband services compared to the rest of the world [40]. The digital divide has a significant impact on Education in Africa. The lack of IT skills, coupled with the inability of several schools to offer IT-related courses or access the vast research resources available online, prevents people in Africa from fully benefiting from the information society [40].

As a result of this divide, higher education faces several challenges in adopting 4IR tools for teaching and learning. Despite the many known benefits of 4IR technologies, there is a need to revise curricula to align content with technological advancements. According to the author [43], while 4IR technologies enhance teaching and learning, higher education institutions must adapt their curricula to integrate these technological systems. Although e-learning is a 4IR tool and a vital global system in higher education, its implementation may threaten the sustainability of institutions with limited technological resources, particularly those in rural areas [44]. The official policy for marginalised institutions remains a critical component of the 4IR in higher education [45]. To facilitate the transition to 4IR, government bodies should provide financial support to improve the infrastructure of rural institutions [44]. The lack of digital culture, training, and technical knowledge further negatively impacts the advancement of teaching and learning in higher education [46]. To address the rapid rate of change, complexity and instability in employment markets, new frameworks should be developed in line with career and technical education [47].

In higher education institutions, more emphasis is placed on the technical capabilities of ICT than on meeting educational needs, which presents a significant challenge [48]. Similarly, the author's study [49] highlighted that the primary barriers to effectively integrating 4IR tools in educational institutions include the absence of technological policies, insufficient equipment, a lack of skilled personnel in technology integration and maintenance, as well as persistent technical issues.

## CONCLUSIONS

The Fourth Industrial Revolution (4IR) presents opportunities and challenges for tertiary institutions in Africa. The inclusion of AI in curriculum formation is a step in the right direction in pre-

paring African tertiary institutions for participation in the Fourth Industrial Revolution. Institutions can enhance teaching processes, design customised learning experiences, and improve curriculum design through the use of Artificial Intelligence technologies.

However, overcoming issues of limited funding, a shortage of infrastructure, and a shortage of ade-

quately trained staff is an essential step toward successfully implementing Artificial Intelligence. Besides advancing academic performance, African universities that incorporate Artificial Intelligence in curriculum design will also equip graduates with the right skills and knowledge necessary for success in today's digital era.

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