

A NEW DAWN IN AFRICA: TOWARDS AN INTEGRATION OF ARTIFICIAL INTELLIGENCE INTO AFRICAN EDUCATION SYSTEM

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ABSTRACT:

The foundation of any society is anchored on the provision of quality education. Recognizing education as a vital asset necessary for comprehensive development and international prominence, societies across the globe strive to ensure that their citizens have access to high-quality educational opportunities. In this context, the rapid advancements in science and technology have been eagerly embraced by nations aiming to enhance their educational frameworks. Such a technological breakthrough is Artificial Intelligence (AI), which possesses the remarkable ability to transform educational practices by facilitating both teaching and learning processes while expanding access to quality education. Western nations have historically taken the lead in this endeavour, diligently working to integrate AI into their educational systems and reaping significant benefits from its implementation. Against this backdrop, this paper conducts a thorough examination of AI, exploring how its transformative potential can be harnessed to enhance teaching and learning within the African education system. This inquiry is guided by two critical research questions: What are the prospects of AI in Africa's education landscape? What challenges accompany the integration of AI into this educational framework? These questions will shape the central focus of our discussion. The paper employs a method of descriptive analysis, drawing on a range of secondary sources, including academic journals and online materials, to effectively address these inquiries.

Keywords: Education, African Education system, Artificial Intelligence (AI).

Introduction:

The pervasive presence of technological tools in today's world has transformed into a global village, with innovations permeating every facet of society to enhance productivity and simplify daily life. This technological evolution has made significant inroads into the educational sector, which serves as the backbone of any society. The quality of education directly influences a country's overall development, prompting nations worldwide to mobilize efforts towards providing high-quality education to their citizens by leveraging new technologies. A notable development in this wave of technological advancement is Artificial Intelligence (AI), which has made substantial inroads across various global sectors. According to Onaolapo and Onifade (2020), AI is gradually revolutionizing industries such as healthcare, energy, agriculture, finance, and manufacturing, positioning itself as a key driver of sustainable development. Education, broadly defined to encompass not only formal schooling but also diverse forms of teaching and learning coordinated by educational institutions, intergovernmental organizations, non-governmental organizations (NGOs), businesses, and government agencies, is also reaping the benefits of AI. These technologies provide solutions to the limitations associated with traditional teaching and learning methodologies, thereby improving access to education, enhancing its quality, and enriching the overall educational experience, all of which contribute to the achievement of Sustainable Development Goal

4. Western nations have traditionally led the way in integrating AI into their educational systems, thereby reaping its significant advantages.

In this context, this paper presents a comprehensive examination of AI and its potential to enhance teaching and learning within the African education system. This investigation is guided by two fundamental research questions: What are the prospects of AI in Africa's educational landscape? What challenges hinder its integration into the continent's education systems? These inquiries will form the crux of our discussion. The paper adopts a descriptive analysis method and utilizes a range of secondary sources, including academic journals and online resources, to address these questions. The first section provides an overview of the state of education in Africa, followed by an exposition of the concept of Artificial Intelligence in the second section. The third section explores the global application of AI in education, while the fourth section delves into the prospects and challenges of integrating AI into Africa's educational framework. Finally, the study concludes with a synthesis of the findings and implications for the future.

An Overview of the State of Education in Africa

Education in Africa presents a complex and multifaceted landscape influenced by a variety of cultural, economic, and social factors (Oketch, 2023). Despite the progress made over the years, the continent continues to grapple with significant challenges in delivering equitable and quality education for all (Baskara, Puri, & Wardhani, 2023). Notable advancements have been achieved in increasing access to primary education, with many countries either reaching or making strides toward universal primary education. However, certain regions still encounter obstacles in ensuring equal access, particularly in remote and conflict-affected areas. Gender disparities in educational access remain a pressing concern, as girls often face greater barriers to enrollment and retention.

Efforts to enhance educational quality have included curriculum reforms, teacher training initiatives, and the integration of technology in select areas. Nevertheless, quality concerns persist in various regions, attributed to outdated curricula, insufficient teacher training, and a lack of resources that undermine educational effectiveness. While infrastructure development has progressed with the construction of additional schools and the provision of essential resources such as textbooks, challenges remain, including classroom shortages, inadequate teaching materials, and uneven resource distribution between urban and rural areas. Addressing teacher shortages through training programs and recruitment initiatives has been a focus, yet the scarcity of qualified teachers endures, particularly in remote and underserved locations. In some cases, teachers may receive inadequate training and professional development opportunities (Govender et al., 2023; Nwosu et al., 2023).

Additionally, there has been a notable expansion of tertiary education institutions across the continent. Access to higher education, however, continues to pose challenges for many, stemming from limited capacity, financial constraints, and a disconnect between educational outcomes and labour market demands. Some countries have implemented multilingual education policies to address language diversity, yet the choice of language of instruction remains a complex issue that can significantly affect learning outcomes. Efforts to incorporate technology into education aim to bridge the digital divide (Tshukudu et al., 2023); however, disparities in access to technology and the internet persist, limiting the effectiveness of e-learning initiatives. In conflict zones, educational disruptions often lead to the closure of schools and the displacement of students and teachers, making the rebuilding of educational systems in post-conflict regions a formidable challenge (Chisom et al., 2023).

Moreover, there is an increasing recognition of the importance of entrepreneurship and vocational training in equipping students with practical skills. However, vocational training opportunities remain limited, highlighting the need for stronger connections between education and employment. Innovative approaches, such as mobile learning and partnerships with technology companies, NGOs, and international organizations, are generating new opportunities. Nonetheless, sustaining and scaling up these innovations poses challenges, underscoring the necessity of collaboration for success. Despite these obstacles, there is a growing commitment among African nations and the international community to address these issues and develop an education system that promotes inclusivity, innovation, and sustainable development. Ongoing efforts emphasize improving access, enhancing quality, and aligning education with the evolving needs of the job market (Chisom et al., 2023).

Towards an Understanding of Artificial Intelligence (AI):

Artificial Intelligence (AI) is an expansive term that encompasses a variety of technologies and systems rather than being confined to a single machine. It includes advancements such as machine learning, data mining, and network processes (Nthabiseng & Oluwatoyin A, 2024). According to Mnguni (2024), defining AI precisely has posed a challenge for scholars, as the field is continuously evolving with ongoing contributions from researchers. AI is increasingly perceived as a force capable of taking over jobs and responsibilities traditionally held by humans. In this regard, Siau (2018), along with Nthabiseng & Oluwatoyin A (2024), characterizes AI as the "ability and development of information technology-based computer systems or other machines to perform tasks that typically require human beings" (p. 19). Supporting this view, Baker & Smith (2019, as cited in Nthabiseng & Oluwatoyin A, 2024) describe AI as computers that undertake cognitive tasks usually associated with human intelligence, particularly in learning and problem-solving (p. 19).

Onalopo & Onifade() provide a broader definition of AI, referring to computing systems that can engage in human-like processes, including learning, adapting, synthesizing, self-correcting, and utilizing data for complex processing tasks. The core concept of AI involves the creation of intelligent machines that can learn from their environments through data collection and analysis, thereby replicating tasks traditionally performed by humans. Consequently, AI presents an opportunity to overcome the limitations of conventional teaching and learning methods, ultimately enhancing access to quality education. AI is thus characterized as a collection of information and communication technologies (ICTs) that emulate human intelligence to enable machines to perform tasks more efficiently, thereby fostering economic growth.

The advancements in artificial intelligence have garnered significant academic and public interest, prompting analyses of its potential to transform societies and its disruptive effects across various industries (Arakpogun et al., 2021). Although definitions of AI differ within the literature, they are generally rooted in the concept of non-human intelligence programmed to execute specific tasks (Dwivedi et al., 2019). While John McCarthy first coined the term "artificial intelligence" in 1956, the underlying concepts existed well before the 1950s (Anyaocha, 2017; Plant, 2012; Smith, 2006; & Spector, 2006). Thus, although AI has evolved through various industrial revolutions—namely the first, second, and third—its significance has surged in the context of the Fourth Industrial Revolution (4IR). This heightened attention stems from the critical role of ICTs in propelling socio-economic development (Arakpogun et al., 2021). AI is accelerating the 4IR at an unprecedented and exponential rate compared to the linear progression of earlier industrial revolutions (Schwab, 2016). Its applications span diverse sectors, including agriculture, banking, education, and health care, and its potential continues to unfold. Estimates suggest that by 2030, AI could contribute over \$15 trillion to the global

economy, resulting in a more than 20% increase in the GDP of local economies as humans and robots collaborate to address pressing global challenges (PWC, 2017; Schoeman et al., 2017).

Recent Developments of Artificial Intelligence (AI) in Africa

The ongoing expansion of artificial intelligence (AI) worldwide is mirrored by the emergence of AI ecosystems across Africa. Leila Janah, the founder and CEO of Samasource, emphasizes that "if you use a mobile phone or laptop's facial recognition features, drive a car, or shop online, there's a good chance that a person in East Africa helped train the algorithm that makes your technology work" (2018). This illustrates the significant role African individuals play in the development of AI technologies. Various local and international AI research hubs have been established to further this growth, such as the Robotics and Agent Lab (RAL) at the University of Cape Town, which was founded in 2007. RAL focuses on robotics and computational intelligence while empowering children from low-income households through their participation in RoboCup Junior, an international robotics competition (Arakpagun et al.).

Data Science Africa (DSA), operational since 2013, is a Kenyan non-governmental organization dedicated to promoting the affordability, broader deployability, and relevance of AI solutions in the African context (Arakpagun et al.). DSA serves as a platform for AI practitioners and researchers across the continent to exchange knowledge and discuss the development and application of AI through summer schools and workshops held in Ethiopia, Ghana, Kenya, Nigeria, Tanzania, and Uganda. Notably, DSA has trained over 200 individuals in machine learning techniques and data science applications, leveraging the Internet of Things (IoT) and social media data analytics. The outcomes of this training have led to the creation of applications in agriculture, disaster management, and healthcare (Arakpagun et al.).

Additionally, the Women in Machine Learning & Data Science (WiMLDS) organization has established chapters in Algeria, Botswana, Kenya, Morocco, Nigeria, and Uganda to encourage women's participation in AI. WiMLDS is pivotal in amplifying women's voices in the field, and addressing concerns regarding the lack of diversity and gender bias in AI (Feast, 2019). Furthermore, IBM Research opened AI labs in Nairobi, Kenya, and Johannesburg, South Africa, in 2013 and 2016, respectively. In 2019, Google followed suit by establishing an AI lab in Accra, Ghana (Feast, 2019). Both Google and IBM labs are developing AI solutions aimed at improving food production and health care across the continent.

While the majority of academic and industry research hubs focused on AI have traditionally been located in advanced and affluent regions like Silicon Valley in California and Zhongguancun in Beijing, a recent shift towards African countries is promising. This shift has resulted in the emergence of approximately 100 AI start-ups across various regions in Africa (Arakpagun et al.). Collectively, these start-ups have raised over \$140 million in seed funding, with a significant portion allocated to the fintech sector in Nigeria. Notable examples include Cellulant, which has secured \$47.5 million, followed by Mines.IO, which raised \$17.2 million (Tsado, 2019). While Nigeria has attracted the largest amount of seed funding, South Africa leads with the highest number of AI start-ups (26), followed by Nigeria (20) and Kenya (9). Tunisia and Zimbabwe each host six AI start-ups, while Egypt and Ghana have five each.

Interestingly, despite Nigeria's leading position in AI seed funding, countries such as Kenya, Tunisia, Mauritius, South Africa, and Ghana rank higher in terms of government readiness for AI implementation (Arakpagun et al.). Although the fintech sector has attracted the largest share of seed funding, the healthcare sector boasts the highest number of AI start-ups (21), followed by agriculture (14) and manufacturing (5). Most of these start-ups were established roughly a decade after the inception of the Fourth Industrial Revolution (4IR), which began in

2000 (Prisecaru, 2016). However, this landscape indicates that African countries are lagging behind the rest of the world. This observation aligns with the 2019 Government AI Readiness Index released by Oxford Insights and the International Development Research Centre, which found no African country among the top 50 of the 194 analyzed (Oxford Insights, 2019). This trend reflects PWC's (2017) projection that Asia (particularly China) and North America will capture the majority of economic benefits from AI, accounting for nearly 70% of the projected \$15.7 trillion contribution of AI by 2030. This reality underscores the pressing need to integrate AI into education across Africa. For instance, Nigeria's Gradely AI start up exemplifies the application of AI in the educational sector. This company utilizes AI to analyze students' learning patterns and outcomes, developing a personalized learning tool kit that assists schools and parents in real-time interventions to address gaps in learning. However, this initiative represents only a minor contribution to the broader educational landscape, highlighting the urgent need for a comprehensive integration of AI within the educational framework across the continent.

Artificial Intelligence and Education

Globally, artificial intelligence (AI) is becoming increasingly integrated into education due to its substantial benefits. The necessity of incorporating AI into educational systems has become imperative to meet the demands of today's fast-paced world. Chisom et al. (2023) support this notion, emphasizing that:

Artificial Intelligence (AI) has the potential to revolutionize education, transforming it from a system focused on memorizing facts into one that helps students unlock their full potential and learn necessary skills through more personalized learning. AI in education is applied to improve learning outcomes and supports teachers in developing better educational practices. From automatic assignment grading to tailored curriculums, there are many ways AI consultants can help educational institutions make use of the technology. AI-based platforms can collect and analyze student data on interaction with educational materials, exercise completion time, test results, and overall performance to understand each student's attitudes and needs. Drawing on this data, AI tools can design personalized training pathways and adapt them in real time to the learner's progress. AI can also predict student performance and identify students who may be at risk of falling behind. AI can automate mundane teacher tasks, such as grading assignments, freeing up time for teachers to focus on more important tasks. AI can also help teachers identify areas where students need extra help and provide them with the necessary resources. AI can also help students with special needs by providing them with personalized learning experiences. AI can also help educational institutions with resource planning, curriculum design, and ongoing assistance during learning (p.644).

Globally, the integration of artificial intelligence (AI) in education has gained significant traction, evidenced by a variety of noteworthy case studies and pilot projects. These initiatives aim to leverage AI technologies to improve learning outcomes, create personalized educational experiences, and address specific challenges within the education sector (Chisom et al., 2023). One prominent example is Squirrel AI, an adaptive learning platform that customizes learning experiences for students through AI-driven insights (Wang et al., 2023). By evaluating

individual student performance, the platform identifies learning gaps and tailors lessons accordingly (Knox, 2020, in Chisom et al., 2023). Pilot projects in various Chinese cities have reported significant improvements in student performance, particularly in mathematics, where the AI system provides targeted support (Yuan, 2023). Another notable initiative is DreamBox, an AI-powered math learning platform designed for K-8 students (Chetradevee et al., 2022). This platform adapts in real-time to students' responses, delivering personalized lessons tailored to their needs. Pilot projects conducted in U.S. schools have demonstrated positive results, with students showing increased engagement and enhanced math proficiency (Chine et al., 2022).

Zaya Learning Labs exemplifies the innovative use of artificial intelligence (AI) in enhancing educational experiences, specifically in India, by delivering personalized and adaptive learning pathways for students (Kaur, 2016). This platform is dedicated to improving literacy and numeracy skills, with pilot projects conducted in rural and underserved regions revealing promising outcomes. Students in these areas have benefited from tailored learning paths that cater to their unique needs. In a different vein, IBM Watson Education leverages AI to support educators and enrich the overall learning experience. This platform offers a suite of tools designed for personalized learning, data analytics, and cognitive tutoring. Pilot initiatives across various countries have investigated the role of AI in augmenting teacher capabilities and providing actionable insights for more effective instruction. Robolink is another noteworthy platform that integrates AI and robotics to teach coding and STEM concepts to students (Tremblay & Padir, 2013). By providing interactive, hands-on learning experiences, Robolink has been shown through pilot projects in South Korean schools to enhance students' problem-solving skills and foster creativity through the integration of robotics and AI into the curriculum.

Additionally, Kolibri serves as an open-source learning platform that utilizes AI to deliver educational resources in offline environments, making it especially valuable for learners in low-resource settings (Cruz et al., 2021; Myers et al., 2022). Pilot projects in countries with limited internet access have demonstrated the efficacy of AI in providing essential educational content without reliance on online connectivity. Aula stands out as a communication and collaboration platform tailored for higher education institutions, employing AI to facilitate personalized learning experiences and enhance student engagement (Jørgensen, Valtysson, and Pagh, 2023). Pilot projects within universities have illustrated significant improvements in student interaction, communication, and collaboration through the implementation of AI-driven features. It is essential to recognize that the impact and success of these initiatives can vary, underscoring the necessity for ongoing research and evaluation to comprehend the long-term effects of AI in educational contexts. The field remains dynamic, with new projects and advancements emerging continuously. Currently, these examples offer valuable insights into how AI is being deployed to tackle diverse educational challenges across the globe (Chisom et al., 2023).

Prospects of Integrating Artificial Intelligence (AI) into African Education System

In examining the historical evolution of education, technology stands out as a crucial force, consistently reshaping learning dynamics and enhancing teaching methodologies. From the ancient abacus to modern calculators and the recent shift to online teaching necessitated by the global pandemic, technology has continually influenced educational practices worldwide (Bendada.com, 2023). The adoption of artificial intelligence (AI) in African education is still in its nascent stages. However, integrating AI capabilities into the educational framework presents significant advantages for both educators and learners, facilitating personalized

academic journeys, improving outcomes, and better-equipping individuals for future challenges (Strongbytes, 2019). AI possesses the potential to revolutionize learning environments across the continent. As Africa confronts pressing issues related to access, quality, and inclusivity in education, AI emerges as a transformative agent capable of addressing these challenges (Chisom, Unachukwu, & Osawaru, 2023). The potential impact of AI in African education is far-reaching, encompassing benefits for students and teachers alike, as explored further below.

In the evolving landscape of African education, the integration of AI becomes especially significant in the realm of language education. The continent's rich linguistic diversity, often perceived as a challenge, presents an opportunity for effective language learning through the strategic deployment of AI in educational platforms. This approach not only meets the practical demand for efficient language education but also serves as a vital tool for cultural preservation (Nyakundi et al., 2024). Nyakundi et al., (2024) highlight this potential in their report, emphasizing the multifaceted advantages of incorporating AI into language education initiatives. They assert:

The infusion of AI goes beyond a mere technological addition; it signifies a paradigm shift in how education stakeholders, including edtech startups, schools, and universities, conceptualise and achieve their objectives. AI becomes a catalyst for innovation, offering a unique blend of technological advancement and cultural heritage preservation in the African educational sphere (pp.9-10).

Furthermore, Nyakundi et al. (2024) assert that AI's data analysis capabilities play a crucial role in informing education policymakers about students' needs, which aids in the design of curricula that align with real-world demands. By integrating AI insights into curriculum development, African educational systems can better equip learners with the relevant skills needed in the job market, thereby fostering a generation of workforce-ready graduates. The importance of AI in supporting and empowering teachers in Africa cannot be overstated. AI-driven professional development tools offer personalized training, resources, and feedback, while intelligent grading and assessment systems alleviate the burdens of manual evaluation. This enables educators to focus more on instructional support. Moreover, data-driven insights facilitate teachers in identifying areas for improvement, allowing them to tailor their teaching strategies to meet the unique needs of their students.

Dabingaya (2022) highlights this potential by noting that AI-powered adaptive learning platforms customize educational content to align with individual student's needs and learning styles, thereby fostering a personalized learning experience. This approach is particularly impactful in accommodating diverse learning abilities and preferences. Additionally, AI's language processing capabilities can help to surmount linguistic barriers by providing multilingual support, enhancing accessibility for students whose primary languages may not be adequately represented in traditional educational materials. Discussing the transformative potential of artificial intelligence in African learning environments, Onaolopo & Onifade (2020) echo the sentiments of Watson (2008), who noted that:

AI could also reinforce student learning by combining technology interface with face-to-face interaction as blended learning. Before the advent of AI and other modern instructional technologies, learning in educational institutions was predominantly based on physical interaction between instructors and students. Though this traditional model was effective in educating a limited number of students at a given time,

constraints such as geographical barriers, limited space and time difference must be resolved to get the best experience out of such a learning exercise. The application of AI tools could remove barriers associated with conventional learning methods and recreate unique classroom experiences for reinforced learning activities. Blended learning is richer for many reasons, for instance in allowing for diversity in learning pathways and reinforcing learning sessions. Blended learning combines the online delivery of educational content with the best features of classroom interaction and live instruction in such a way as to personalize learning, allow thoughtful reflection, and differentiate instruction from student to student across a diverse group of learners (p.4).

In a similar vein, Chisom et al. (2023) underscore the vast potential and advantages of artificial intelligence in educational contexts, highlighting the significant promises it holds for integration into the African education system. They argue that AI-driven virtual tutors and chat bots offer essential support for students, particularly in remote or underserved areas where access to qualified educators is often limited. By analyzing data on student performance, engagement, and learning patterns, AI empowers educators with valuable insights that facilitate informed decision-making and timely interventions. Moreover, AI tools assist teachers in developing engaging lesson plans, grading assignments, and providing real-time feedback, all of which contribute to enhancing the overall quality of teaching and learning. Additionally, AI can be harnessed to create gamified learning experiences, making education more interactive and enjoyable for students. This innovative approach not only boosts motivation but also improves knowledge retention. AI algorithms are adept at identifying early signs of learning difficulties or gaps in understanding, enabling timely intervention and support for students who may be struggling. AI's capacity for customizing educational content based on student progress ensures that curricula align with individual learning trajectories. Furthermore, it aids educational institutions in optimizing resource allocation, effectively managing classrooms, and scheduling teaching staff (Chisom et al., 2023).

Leveraging AI for mobile learning initiatives is particularly advantageous in bridging the digital divide, allowing access to education for students in remote areas with limited resources. Automated assessments powered by AI offer nuanced insights into students' comprehension levels, facilitating a more comprehensive evaluation of their skills and knowledge. This transformative approach to evaluating academic performance presents numerous innovations and benefits. For instance, AI enables adaptive assessments that adjust the difficulty of questions based on students' responses, ensuring personalized evaluations tailored to individual learning levels. The automation of the grading process allows for immediate feedback, fostering a deeper understanding of the material and enabling quick identification of areas needing further attention. By evaluating responses based on predefined criteria, AI minimizes subjective biases, thus ensuring a more objective and consistent assessment process (Chisom et al., 2023).

AI's ability to analyze large data sets provides educators with comprehensive insights into students' performance patterns, strengths, and areas for improvement, informing targeted interventions. Additionally, AI assessments can identify specific knowledge gaps or misconceptions, allowing educators to tailor instructional strategies to meet individual student needs. The automation of scoring not only saves educators considerable time but also allows them to focus on instructional planning and support. Furthermore, AI supports the creation of assessments in various formats—text, images, and audio—thereby accommodating diverse learning styles and facilitating a more holistic evaluation process. Continuous formative

assessments enable educators to monitor student progress throughout the learning journey, allowing for timely adjustments to teaching strategies. Finally, AI can incorporate anti-cheating measures, such as plagiarism detection and facial recognition, enhancing the integrity and security of online assessments. Ultimately, AI assessments provide valuable insights into students' unique strengths and weaknesses, empowering educators to adapt their teaching strategies accordingly (Chisom et al., 2023).

AI tools play a crucial role in supporting educators by facilitating the creation of engaging lesson plans, streamlining the grading process, and delivering real-time feedback. Such support significantly enhances the overall quality of teaching and learning experiences. Moreover, AI can be utilized to develop gamified learning environments, transforming education into a more interactive and engaging endeavour for students. This innovative approach not only boosts motivation but also improves knowledge retention. Furthermore, AI algorithms are capable of detecting early signs of learning difficulties or gaps in understanding, enabling timely interventions and assistance for students who may be struggling. By customizing educational content following individual progress, AI ensures that curricula align with each student's unique learning trajectory. Additionally, AI aids educational institutions in optimizing resource allocation, effectively managing classrooms, and efficiently scheduling teaching staff. The advent of AI-driven assessments marks a transformative shift in evaluating academic performance, bringing forth numerous innovations and advantages (Chisom et al., 2023).

These assessments can precisely identify specific knowledge gaps or misconceptions, allowing educators to tailor instructional strategies to meet individual student needs. The automation of assessment scoring not only conserves valuable time for educators but also enables them to concentrate on instructional planning and support. The integration of AI technologies is crucial for fostering a future where learning is continuous, accessible, and personalized to individual aspirations. In addition to facilitating self-paced learning, AI introduces diverse educational options that can address various learning disabilities. The use of AI technologies such as tutoring software, robots, and humanoid assistants has demonstrated significant benefits in enhancing the educational experiences of students with Autism Spectrum Disorder (ASD). Likewise, tools like Immersive Reader serve as AI services that improve reading and comprehension skills through text decoding solutions for students with learning differences, including dyslexia (Onaolapo & Onifade, 2020). By harnessing the power of AI, lifelong learning evolves into a dynamic and personalized journey, empowering individuals to adapt to changing environments, pursue new interests, and remain relevant in the rapidly evolving landscape of work and knowledge.

Challenges Militating against the Integration of Artificial Intelligence into Africa's education system.

Despite the promising potential of AI integration in Africa's education system, significant challenges persist. This study categorizes these challenges into two overarching categories, which are discussed in detail below:

Socio-economic Inequalities Challenge

Africa grapples with significant levels of poverty, which perpetuate a widening gap between the affluent and the impoverished, thereby engendering structural inequalities. These inequalities manifest as disparate access to socio-economic and political resources, including education, employment, income, information and communication technologies (ICTs), and healthcare. Within the global context, many African nations rank among the least developed regarding access to these vital resources (UNHDR, 2018). Given that AI relies heavily on the integration of ICTs, the absence of such resources poses a dual disadvantage—not only for

prospective AI users but also for AI developers. This situation implies that those burdened by structural inequalities, particularly the digital divide, are at a heightened risk of missing critical AI opportunities.

Moreover, African countries exhibit varying degrees of digital divide relative to other regions globally. For instance, while Northern African nations boast an average mobile phone penetration rate of 68%, sub-Saharan Africa lags at 45% (GSMA Intelligence, 2020). The digital divide in Africa is intricately linked to several systemic issues, including inadequate telecommunications infrastructure, insufficient electricity supply, the high cost of smart phones, and a lack of digital skills (Arakpogun et al., 2017). Thus, the digital divide serves as a symptom of deeper societal problems, with existing inequalities extending into the digital realm. This dynamic results in poor AI readiness, as highlighted by the 2019 AI Government Readiness Index, which indicates that many Africans risk being left behind (Oxford Insights, 2019). Rutenberg (2019) further emphasizes the alarming lack of governmental preparedness for AI across African nations, noting that no country on the continent appears among the top 50 in terms of AI readiness. Consequently, a correlation exists between structural inequalities, digital divides, and AI readiness, suggesting that the most disadvantaged populations are likely to miss out on the potential benefits of AI, including enhanced employment prospects, improved educational opportunities, advancements in healthcare, and greater access to e-government services.

Governance, Policy and Security Challenges

The fusion of multiple technologies serves as the foundation for artificial intelligence (AI) and its potential to propel the Fourth Industrial Revolution (4IR). This technological convergence presents novel challenges for governments, particularly concerning regulation. It has been posited that the institutional capacity—encompassing skills and financial resources—of governments to regulate prior industrial revolutions was relatively manageable. This is attributed to the alignment between the pace of public policy decision-making and the linear, mechanistic processes that characterized those earlier periods (Schwab, 2016). Consequently, governments had ample time to devise relevant regulatory frameworks that established rules of engagement while employing limited governance capabilities within the industry (Schwab, 2017).

In contrast, the rapid advancement of contemporary technology, combined with ongoing convergence, renders regulation increasingly complex, challenging, and costly for governments (Janssen, 2020). The formulation of appropriate legal and regulatory frameworks becomes daunting, as these frameworks risk becoming obsolete in light of the continually evolving technological landscape. The intricacies associated with the 4IR necessitate a heightened level of institutional capacity, which is disproportionately lacking in many African nations, coupled with fragile legal and regulatory structures (Arakpogun et al., 2017; Fick & Akwagyiram, 2018). For instance, as reported by Consumer International, only 19 of the 55 African countries had enacted data security and privacy laws by 2018. When focusing specifically on AI, the situation is even more concerning; of the 46 Sub-Saharan African countries, only Kenya has established an AI task force dedicated to developing a national strategy (AI4D, 2018).

Furthermore, the integration of AI into education across Africa necessitates significant policy reforms. African nations must address extensive policy changes to successfully incorporate AI into teaching and learning frameworks. A comprehensive policy framework is essential, which may involve overhauling existing policies and establishing new ones, to foster collaboration among industry stakeholders and create a sustainable environment conducive to the application

of AI in education (Onaolapo & Onifade, 2020). Besaw and Filitiz (n.d.) contend that realizing the positive potential of AI requires robust governance systems, which are integral to the policy framework. Ayoub (2020) underscores the necessity for appropriate AI policies in education, noting that while educators perceive AI as vital for enhancing their institution's competitiveness, most institutions still lack a formal data strategy to promote AI initiatives. Despite the presence of effective ICT policies in many African countries, there remains a significant absence of specific AI policies across the continent.

Compared to Europe, Canada, the United States, and China, Africa lacks a well-documented strategy for artificial intelligence (AI). While there are valuable lessons to be gleaned from these regions, it is essential to recognize that policies cannot be directly imported, as they may not align with the unique contexts and challenges faced by African societies. Consequently, it is imperative to develop relevant policies that provide clear guidance on the application of AI in education, tailored to the distinct characteristics of the African continent (Onaolapo & Onifade, 2020). Supporting this argument, Wilner (2018), as cited in Arakpogun et al. (2017), emphasizes the importance of crafting context-specific strategies to effectively address the educational needs and aspirations of African nations. In his words:

The general lack of institutional capacity and AI regulatory framework across Africa could result in unintended consequences, including the inability of governments to guarantee the data security and privacy of citizens as well as mitigate the impact of cyber and national security. While the threat of cybersecurity has been around since the 3IR (Third Industrial Revolution), the advancement that comes with AI and IoT further complicates personal and national security as critical and life-saving devices are wirelessly tethered together. One implication of this is that state or individual actors could cripple critical infrastructure in a manner that threatens the existence of a nation. As technological advancement like AI develops, it heightens the threat levels of cybersecurity – this should also shift how governments respond to safeguard societies. Therefore, the paucity of comprehensive AI policy frameworks that are relevant to the African context is deeply concerning (p.6)

In alignment with the aforementioned arguments, Arakpogun et al. (2017) contend that contrary to the recommendations of some scholars advocating for African countries to adopt the African Union's Convention on Cyber Security and Personal Data Protection, such a blanket "copy-and-paste" approach has not effectively advanced policy development across the continent. Rather than emulating external models, African governments should embrace a problem-driven approach that contextualizes local needs and challenges within the policy formulation process (Andrews, 2013). This shift would transition AI policy in Africa from a focus on institutional form—how policy should appear—to institutional function—what policy should accomplish (Pritchett et al., 2013). Such an approach would empower African nations to develop robust AI policies tailored to their unique circumstances. Furthermore, effective stakeholder engagement is essential for African governments to ensure that policy development reflects the inputs of a broader community, ultimately fostering an agile institutional capacity capable of governing AI.

In summary, while AI presents significant advantages for teaching and learning, its efficacy hinges on the collection and analysis of personal data from students and faculty members within educational programs. This data collection raises critical concerns regarding privacy and data protection. Safety and security issues associated with AI-based systems involve ensuring

safe usage for humans, as well as the verification, validation, and self-awareness of these systems in potentially adversarial environments. As AI becomes increasingly embedded in educational contexts, participants may face heightened exposure to unintended risks, including the possibility of unauthorized access to their private information. Additionally, since AI relies heavily on data, the quality of its outcomes is directly contingent upon the integrity of the data utilized. If the data input is flawed, there exists a significant risk that AI could yield misleading or detrimental results (Zawach-Richter et al., 2019; Fagbola & Thakur, 2019; Michalski et al., 2013; Arakpogun et al., 2021).

Conclusion

With the evident success of Artificial Intelligence (AI) applications in developed countries, its integration into the African education system represents a transformative leap forward, positioning the continent to compete effectively on the global stage. While AI is not entirely new to Sub-Saharan Africa, evidenced by the presence of various AI startups across the continent that are facilitating its application in sectors such as health and business, the momentum for its integration into education has been relatively slow. This study has thoroughly explored the significant benefits that the incorporation of AI into Africa's education system can yield. Given that education serves as the foundation and primary catalyst for development in any society, addressing the numerous challenges facing education in Africa makes AI integration an essential prerequisite for meeting contemporary global demands in an increasingly fast-paced technological landscape. However, despite the promising prospects associated with this integration, considerable challenges persist, including pervasive poverty, ineffective governance, and inadequate policies and infrastructure, among others. While this study aligns with its objective to examine both the potential benefits and challenges associated with AI integration in Africa's educational framework, it does not provide in-depth solutions to the obstacles hindering this integration. This aspect is intentionally reserved for future research endeavours.

References:

- AI4D. (2019, May 8). A roadmap for artificial intelligence for development in Africa. *Artificial Intelligence for Development in Africa*. <https://ai4d.ai/blog-africa-roadmap> accessed on October 15, 2024.
- Andrews, M. (2013). *The limits of institutional reform in development: Changing rules for realistic solutions*. Cambridge University Press.
- Anyoha, R. (2017). The history of artificial intelligence. *Science in the News - Harvard University*, 1-19.
- Arakpogun, E. O., Wanjiru, R., & Whalley, J. (2017). Impediments to the implementation of universal service funds in Africa—A cross-country comparative analysis. *Telecommunications Policy*, 41(7-8), 617-630.
- Arakpogun, E. O., Elsahn, Z., Olan, F., & Elsahn, F. (2021). Artificial intelligence in Africa: Challenges and opportunities. *The fourth industrial revolution: Implementation of artificial intelligence for growing business success*, 375-388.
- Ayoub, D. (2020, March 4). Unleashing the power of AI for education. *MIT Technology Review* <https://www.technologyreview.com/2020/03/04/905535/unleashing-the-power-of-ai-for-education> accessed on October 15, 2024
- Baskara, F. R., Puri, A. D., & Wardhani, A. R. (2023). ChatGPT and the pedagogical challenge: Unveiling the impact on early-career academics in higher education. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, 5(3), 311-322.

- Bendada. (2023, July 28). How startups can leverage AI to transform education in Africa. *Bendada.com*. <https://www.bendada.com/how-startups-can-leverage-ai-to-transform-education-in-africa> accessed on October 15, 2024
- Besaw, C., & Filitiz, J. (n.d.). Artificial intelligence in Africa is a double-edged sword. *Our World United Nations University*. <https://ourworld.unu.edu/en/ai-in-africa-is-a-double-edged-sword> accessed on October 15, 2024.
- Chetradevee, S. L., Xavier, K. A., & Jayapandian, N. (2022). Artificial intelligence technological revolution in education and space for the next generation. In *Communication and Intelligent Systems: Proceedings of ICCIS 2021*(pp. 371-382). Springer Nature.
- Chine, D. R., Chhabra, P., Adeniran, A., Kopko, J., Tipper, C., Gupta, S., & Koedinger, K. R. (2022, June). Scenario-based training and on-the-job support for equitable mentoring. In *The Learning Ideas Conference* (pp. 581-592). Springer International Publishing.
- Chisom, O. N., Unachukwu, C. C., & Osawaru, B. (2023). Review of AI in education: Transforming learning environments in Africa. *International Journal of Applied Research in Social Sciences*, 5(10), 637-654.
- Cruz, X. M., Honrado, E., Libatique, J. C., Tangonan, L., Oppus, G. M., Cabacungan, P. A., & Mamaradlo, J. P. M. (2021, January). Design and demonstration of a resilient content distribution and remote asynchronous learning platform. In *Adjunct Proceedings of the 2021 International Conference on Distributed Computing and Networking* (pp. 98-103).
- Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., ... & Williams, M. D. (2021). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International journal of information management*, 57, 101994.
- Feast, J. (2019). 4 ways to address gender bias in AI. *Harvard Business Review*, 20
- Fick, M., & Akwagyiram, A. (2018, April 4). In Africa, scant data protection leaves internet users exposed. *Reuters*. <https://www.reuters.com/article/us-facebook-africa/in-africa-scant-data-protection-leaves-internet-users-exposed-idUSKCN1HB1SZ> accessed on October 14, 2024.
- Govender, S., Ajani, O. A., Ndaba, N. H., & Ngema, T. (2023). Making in-service professional development effective in a rural context: Enhancing social justice for rural teachers. In *Contextualising Rural Education in South African Schools* (pp. 78-95). Brill.
- GSMA Intelligence. (2020). *The mobile economy*. GSM Association.
- Janah, L. (2018, December 5). How East Africa trains AI. *LinkedIn*. <https://www.linkedin.com/pulse/how-east-africa-trains-ai-leila-janah/> accessed on October 14, 2024
- Janssen, M., Brous, P., Estevez, E., Barbosa, L. S., & Janowski, T. (2020). Data governance: Organizing data for trustworthy Artificial Intelligence. *Government Information Quarterly*, 37(3), 101493.
- Jørgensen, R. F., Valtysson, B., & Pagh, J. (2023). Working with Aula: How teachers navigate privacy uncertainties. *The Information Society*, 39(4), 225-235.
- Kaur, I. (2016). Blended learning is a convergence of online learning and face-to-face education for imparting better education in India. *PEOPLE: International Journal of Social Sciences*, 2(1), 226-235.
- Mnguni, L. (2024). The curriculum ideologies underlying the AfriMEDS curriculum framework for undergraduate medical and dental education in South Africa. *International Medical Education*, 3(1), 44-61.

- Nthabiseng, B., & Oluwatoyin, A. (2024). A systematic review of artificial intelligence in higher education in South Africa. *Social Sciences and Education Research Review*, 11(1), 17-26.
- Nyakundi, D., Oginga, A., & Omar, S. (2024). The role of artificial intelligence in African education systems: A case study of automated decision-making in Form One placements in Kenya. *Ideate Tech Policy Africa: A report to The Centre for Intellectual Property and Information Technology Law (CIPIT), Strathmore University*, 1-34.
- Oketch, M. (2023). What is the appropriate higher education finance model for Africa? Some reflections. *South African Journal of Higher Education*, 37(6), 131-152.
- Onaolapo, S., & Onifade, T. (2020). Teaching and learning in the cloud: Prospects and Challenges of Artificial Intelligence for education in Africa. In *10th annual international conference on sustainable development (ICSD)* (pp. 1-9).
- Oxford Insights. (2019). *Government Artificial Intelligence Readiness Index 2019*. Oxford Insights and the International Development Research Centre (IDRC). <https://oxfordinsights.com> accessed on October 14, 2024.
- Plant, R. (2011). An introduction to artificial intelligence. In *32nd Aerospace Sciences Meeting and Exhibit* (p. 294). American Institute of Aeronautics and Astronautics.
- Prisecaru, P. (2016). Challenges of the Fourth Industrial Revolution. *Knowledge Horizons - Economics*, 8(1), 57-62.
- Pritchett, L., Woolcock, M., & Andrews, M. (2013). Looking like a state: Techniques of persistent failure in state capability for implementation. *The Journal of Development Studies*, 49(1), 1-18.
- PricewaterhouseCoopers (PwC). (2017). *Sizing the prize: What's the real value of AI for your business and how can you capitalize?* London: PricewaterhouseCoopers (PwC).
- Rutenberg, I. (2019). Africa. In O. Insights, *Government artificial intelligence readiness index 2019* (pp. 9-11). Oxford: Oxford Insights and Canada's International Development Research Centre (IDRC).
- Schoeman, W., Moore, R., Seedat, Y., & Chen, J. Y.-J. (2017). *Artificial intelligence: Is South Africa ready?* Pretoria: Accenture and the University of Pretoria's Gordon Institute of Business Science.
- Schwab, K. (2016, January 14). The Fourth Industrial Revolution: What it means, how to respond. *World Economic Forum*, <https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond> accessed on October 14, 2024.
- Schwab, K. (2017). *The Fourth Industrial Revolution*. Crown Business.
- Smith, C., McGuire, B., Huang, T., & Yang, G. (2006). The history of artificial intelligence. *University of Washington*, 27, 22-24.
- Spector, L. (2006). Evolution of artificial intelligence. *Artificial Intelligence*, 170(18), 1251-1253.
- Strongbytes. (2019, June 14). *AI brings smart learning experiences to schools*. <https://strongbytes.ai/smart-learning-experiences-are-the-future> accessed on October 13, 2024.
- Tremblay, T., & Padir, T. (2013, October). Modular robot arm design for physical human-robot interaction. In *2013 IEEE International Conference on Systems, Man, and Cybernetics* (pp. 4482-4487). IEEE.