

Application of Artificial Intelligence in Education in Africa

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PREFACE

Artificial Intelligence (AI) is creating a seismic shift globally, and education is no exception. As governments in Africa seek to improve and enhance equitable access to quality education, AI presents limitless opportunities on one hand, and significant challenges on the other. This study, therefore, aims to explore the potential benefits and ethical implications of AI's application in the education sector across Africa, with a focus on providing actionable insights for stakeholders and policymakers. It sets out to generate evidence that can be used by stakeholders and policymakers to accelerate the deployment of AI in the education sector, while simultaneously addressing the fears, ethical issues, and challenges that may hinder or slow its widespread adoption. By examining these dynamics, the study expects to contribute to the development of a strategic framework that ensures AI is leveraged effectively and responsibly in the pursuit of quality education in the continent. The insights gathered here are intended to guide policymakers, educators, and technologists in their efforts to harness AI for the purposes of improving education systems across the continent, in a way that fosters inclusion, equity, and quality education for all.

Education offers myriad ways through which AI can be deployed. This include but not limited to personalized learning, monitoring students' progress, intelligent tutoring systems, supporting teachers, improving course content and intelligent tutee. It also offers support to policy-making advisory, simplifies administrative tasks, supports a platform for collaborative learning and enhances access to inclusive education with the potential to reduce the cost of education in Africa. However, despite its potential benefits, deployment of AI in education is fraught with anxiety - both perceived and real. The perceived fears of the negative impact of AI deployment in education include job losses, isolation/ individualization and technology addiction. In addition, AI systems can also breed natural inequality among learners, breach privacy and security, create inequality amongst learners and worsen plagiarism.

Generally, the study covers several key themes that are crucial for understanding the intersection of AI and education on the continent. Firstly, it explores the various avenues through which AI can be integrated into Africa's education systems - from personalized learning to administrative efficiencies, highlighting areas with the most potential for impact. Secondly, it delves into the **impact of COVID-19 on the digitalization of education in Kenya**, examining how the pandemic influenced the digitalization process; and how it accelerated the adoption of digital tools in education globally. Thirdly, **the study documents** notable successes where AI has been effectively implemented in African educational contexts, providing insights into best practices and lessons learned. Concerns around privacy, equity, and job displacement - analyzing both the perceived and actual risks associated with AI in education. Finally, despite the great potential of AI deployment in the education sector across Africa, it faces significant hurdles: infrastructural limitations, digital literacy gaps and ethical concerns.

The study strongly urges African governments to develop mechanisms for collecting AI training data for localized use in the continent, invest in connectivity infrastructure and put in place proper data protection legislation, regulation and standards across. Also, governments should enhance research and investment in education programmes especially for the purposes of building technical competences of future generations.

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ACRONYMNS

AI	Artificial Intelligence
SDG	Sustainable Development Goal
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WEF	World Economic Forum
COVID19	Coronavirus disease 2019
SLR	Systematic Literature Review
ITS	Intelligent tutoring systems
MOOCs	Massive Online Open Courses
DAIA	Decentralized AI Alliance
ATA	Artificial Teacher Assistance
ChatGPT	Chat Generative Pre-Trained Transformer
NLP	Natural Language Processing
SMS	Short Message Service
USD	United States dollar
LMS	Learning Management System
IT	Information Technology
NECTA	National Examination Council of Tanzania
UK	United Kingdom
UNECA	United Nations Economic Commission for Africa
AIED	AI in Education
US	United States
KICD	Kenya Institute of Curriculum Development
R&D	Research and Development

1. CHAPTER ONE

INTRODUCTION TO THE PUBLICATION

1.1 Background

Artificial intelligence (AI) enables machines to undertake tasks previously reserved for human beings faster and more efficiently and therefore the deployment of AI technologies presents huge opportunities to contribute to Africa's prioritized social and economic aspirations. Artificial intelligence is the ability of machines to adapt to new situations, deal with emerging situations, solve problems, answer questions, devise plans, and perform various other functions that require some level of intelligence typically evident in human beings (Coppin, 2004) and thereby presenting a tremendous set of opportunities and benefits to human well-being. AI can improve the way people work by creating new employment and business opportunities and automating tasks; it can improve the efficiency and delivery of public services in all sectors including education, health, climate change, manufacturing, agriculture, and financial services, and garbage collection. It can also strengthen the social fabric of societies by, for example, allowing multilingual societies to communicate more clearly (Brandusescu, Freuler & Thakur, 2017).

Digitalization has been one of the main drivers of innovation in education practices in the classroom (Vincent-Lancrin et al., 2019). While most innovation in the past decade related to an increased use of computers and the internet in the classroom, the next wave will be based on AI, or on combinations of AI and other technologies. Artificial intelligence is embedded in many technological innovations that provide learning analytics, recommendations, and diagnosis tools in various ways and for various purposes. There are many examples of promising uses that predict how AI might transform education in the next decades, both in the classroom and at the system levels, and address different stakeholders: students, teachers, administrators, parents, as well as policy makers. Through this, AI may particularly help achieve some of the global educational targets identified by SDG 4: *"Ensure inclusive and equitable quality education and promote life-long learning opportunities for all"* (Vincent-Lancrin & Vlies, 2020) and can improve education in ways that offer more personalized, flexible, inclusive and engaging learning (UNESCO 2017). AI can revolutionize the education by enhancing teaching methods, course content and other materials, support teachers, predict student performance, evaluate and grade students and improve course contents.

1.2 Statement of the Problem

Despite several potential benefits of artificial intelligence, there are concerns about the potentially negative effects of AI-led automation. The World Economic Forum (WEF), for example, estimates that AI and robotics will absorb 5 million jobs by 2020; many of these positions are expected to be lost in call centers, which have served as an important economic springboard for women in low- and middle-income countries. There is also concern that AI

programmes and decision-making systems supported by AI may include human biases, leading to further discrimination and marginalization. While these opportunities and threats may sound similar to those posed by previous technological innovations, the scale of AI technology magnifies the potential impact. Research by McKinsey suggests that AI could transform society “ten times faster and at 300 times the scale, or roughly 3000 times the impact” of the Industrial Revolution (Brandusescu, Freuler & Thakur, 2017). According to Crafts et al. (2018) AI-enabled changes could affect the quantity and quality of work. The potential of AI to drive change in many employment sectors has revived concerns over automation and the future of work.

These concerns and fears are expected to be found in the education sector. Recent systematic reviews show that AI in Education has been a field of research concentrated in developed countries (Roll & Wylie, 2016). As part of an advance technological discussion that builds upon firmly developed infrastructure and knowledge ecosystems, AI in Education is a neglected topic in the developing world, Africa included. The field of education is just beginning to respond to the opportunities and challenges of living in an AI world. However, the penetration of AI in education comes with concerns about ethics, security and human rights. Without policy intervention, the commercial deployment of AI will also worsen digital divide and deepen existing income and learning inequalities, as marginalized and disadvantaged groups are more likely to be excluded from AI powered education (UNESCO, 2019).

For the stakeholders in the education sector including the policy makers to realize the potential of AI, it is necessary for them to have a solid understanding of its benefits, fears and perception, challenges of deployments, the state-of-play of AI systems, and its complex ethical and legal implications (Southgate et al., 2018). This study aims to contribute towards filling this gap.

1.3 Justification for this publication

A publication on role and impact of AI in education in Africa would be appropriate for several reasons. First, it will add to existing knowledge on AI in education in Africa. Secondly, it will also unearth how Africa can leverage on the benefits that AI can offer in education in order to enhance learning outcomes and solve some of challenges they face in education. This will enable educators and policy makers to lay strategies on how to successfully adopt and use AI in education in Africa. Finally, arising from the experience of COVID-19 pandemic, the time to embrace AI in education is now. To contain the rapid rise of COVID-19 infections, countries-imposed travel ban; lockdowns, handwashing and observing social distance. These measures forced over 1.2 billion children in 186 countries to stay at home due to school closures (WEF, 2020). In Africa, most learning institutions were closed and only a few with eLearning resources were able to provide some distance learning. Inequitable access to eLearning can widen the inequalities and infringement of the right to quality education for the vast majority of the children in many countries (Bett, 2021). The biggest beneficiary of the COVID-19 pandemic is eLearning. There is a sudden surge in demand for online learning in African countries and it is expected to continue thereafter. Whereas there are concerns that the unplanned and rapid move to online learning will result to poor user experience that may negatively affect growth, it is projected that a new hybrid model of education will emerge, with significant benefits (WEF 2020).

This publication on the role and impact of AI in education that will benefit various stakeholders in the education sector in Africa. It will contribute to the growing study and development of knowledge and findings that identify and discuss the different ways in which AI has impacted education. It will benefit scholars, professionals, and policy makers, such as administrators,

management and leadership of educational institutions and the education sector. It will also be more relevant to students as they need to be equipped with the most probable practices regarding AI applications and to be helped to become aware of and ready for the expected AI transformation in the education field. This publication is expected to enhance adoption and deployment of AI in education in Africa.

1.4 Purpose and Objectives

The overall objective of this study was to generate evidence that can be used by stakeholders and policy makers to accelerate the deployment of artificial intelligence in the education sector while providing measures to address any fears and ethical issues as well as challenges that may affect the deployment of AI to a scale that can have impact in the education sector in Africa. The study covered the following themes:

- a. Possible areas of deployment of AI in education in Africa.
- b. Impact of covid-19 on the digitalization of education in Kenya.
- c. Success stories of AI deployment in education in Africa.
- d. Perceived and real fears and negative impacts of AI in Africa's education system.
- e. Key challenges to deployment of AI in education in Africa.

1.5 Methodology of preparing the publication

The project was undertaken mainly through desk study and employed qualitative research design. The study used the Systematic Literature Review (SLR) method, based on the work of Kitchenham et al., (2009). The advantages of the SLR method are that it offers insights into a research problem and enables a study to gather the available information from a wide range of sources (Kitchenham & Charters, 2007). In addition, SLR results are more reliable and more likely to be unbiased compared to unstructured methods such as the simple literature review (Stapić et al., 2012). SLR consists of three main phases, namely, planning, conducting and reporting, as described by Kitchenham et al., (2009).

- a. **Planning the review:** The planning phase involved determining the research questions, keywords, resources to be searched, inclusion and exclusion criteria and data extraction strategy. To achieve the research objectives, we conducted excessive document review and reports of AI in education sector in an online mode. In order to find literature for the current overview, we used electronic databases as the most efficient way to begin literature search, in particular, ScienceDirect, GoogleScholar, and Emerald. We also searched the reference lists of the relevant primary studies manually to ensure the completeness of our search. While looking for other locations that are appropriate for finding the information we needed, we considered also some scientific journals, whose scope lies in the field of Artificial Intelligence and education, such as: International Journal of Artificial Intelligence in Education; Computers and Education; Computers and Human Behaviour. As AI is emerging technology, we also include some information from magazines, journals, and newspapers such as Forbes, AI Magazine and governmental reports.

- b. Conducting the review and reporting:** Conducting of the review involved three steps – identification and selection of research studies, quality assessment of the identified studies, and data extraction. A quality assessment checklist was adopted from Kitchenham and Charters (2007) to assess the quality of the evidence presented by the selected studies. In the data extraction step, we focused on and recorded the impact of AI in education in every study.

2. CHAPTER TWO

RESULTS AND DISCUSSIONS

➤ 2.1 Possible areas of deployment of artificial intelligence in education

2.1.1 Personalized learning

Most of the studies reviewed identified personalized learning as one of the most important roles of AI in education. Personalized learning (PL) is a key area in which AI can impact African education system. PL involves understanding the current learning position of a student and creating personalized plans to improve it (Elhoussein et al., 2024; Nzoka, 2024). AI can help construct the individual learning plans of students based on their strength, weaknesses, activities, and learning preference. Personalized learning can improve student achievement no matter what their starting level is. All students are different and approach learning differently, and while teachers cannot manage to personalize their teaching methods for a whole class, nor can they provide one-on-one sessions for everyone, it seems like AI can be of great help here¹. AI can bring the following benefits to personalized learning:

- a. **Optimal resource allocation:** According to Onaolapo and Onifade (2020). AI allows smart learning as African students can have personalized learning instructions in their areas of interests. With the help of AI, homework and classes could be customized based on student's ability, needs and interests, while their overall performance in the assessments could be analyzed to determine relevant resources to help students understand the assigned tasks. AI will play a vital role of a personalized learning resource allocator for students, thereby helping teachers focus more on facilitation, while technology handles the intricacies of teaching and learning, assessment and resource distribution¹.
- b. **Managing huge number of students:** Public and private schools in Africa have a large size population of learners, with few teachers who can barely handle individual learning demand of their students. Personalization becomes a challenge when a teacher is dealing with a high number of students in the traditional way of teaching (Ahmad et al., 2020; Nji, 2024). AI will bring a differentiated service that will help the teacher harness the power of AI to personalize the experience of students (Bowman,2023).
- c. **Reduce learning inequality:** Additionally, AI will potentially eradicate learning inequality in Africa (Bowman, 2023). It provides marginalized people and communities, people with disabilities, refugees, those out of school, and those living in isolated communities with access to appropriate learning opportunities (UNESCO, 2019). With the advancement in AI, African students can have access to personalized instruction in real-time with adequate

¹ Jude, "Artificial Intelligence as an Assessment tool for Education in Africa".

feedback (synchronous learning) and as self-paced interaction with flexible schedules (asynchronous learning). AI could also advance quality education with highly personalized teaching programs for all ages across the world².

- d. **Improve students' progress:** According to (Rasugu,2019; Elhussein et al., 2024), AI helps educators have greater insight as to how students are progressing. That means they could adjust their approach, supporting students' individual needs. Using tools such as Azure's Machine Learning software, they can analyze student data and predict their probability of passing. This then allows educators to proactively address learning challenges before they become a problem. Furthermore, Onalapo and Onifade (2020) notes that the use of AI could provide African teachers with adequate information on unique attributes of individual students which could influence their career paths.

2.1.2 Intelligent tutoring systems

Several studies have demonstrated the effectiveness of intelligent tutoring systems (ITS) to promote learning outcomes (Ahmad et al., 2020; Makala, Schmitt & Caballero, 2021). ITS systems play a major role to plug the growing gap between the increasing number of learners and the shortages in qualified specialist teachers globally. According to (Hwang et al., 2020; Nji, 2024) an AI application might play the role of a tutor who observes students' learning processes, analyzes their learning performance, and provides instant assistance to them based on their needs. Intelliverse AI, 2023 notes that intelligent tutoring systems can provide real-time feedback and guidance to both students and teachers. AI-powered assessment tools can help identify areas where students are struggling and provide targeted interventions. This can enable teachers to address individual learning needs more effectively and improve overall learning outcomes.

Based on the potential needs of students, an interdisciplinary team can develop an intelligent tutoring system that enables students to learn, practice, and interact with peers or teachers but also provides hints, guidance, and supports to individuals based on their status or needs. AI might provide diverse learning options; some of which may also tackle learning disabilities. The use of AI such as Tutoring Software, robots and humanoids has shown benefits in enhancing the learning experience of students with Autistic Spectrum Disorder (ASD). Similarly, Immersive Reader is an AI service which enhances reading and comprehension through text decoding solutions for students with learning differences such as dyslexia³.

2.1.3 Support teachers

Several studies indeed agree that AI can play the role of supporting the teacher (Ahmad et al., 2020; van der Vorst et al., 2019). One major opportunity for AI in education is the role that AI can play in solving workload related problems experienced by teachers in Africa. This increased workload is partly due to additional administrative tasks that teachers have been given with the existing range of tasks as well as due to reduction of new teachers entering the work force. AI can support the teacher in the following manner:

- a. **Teacher's instructional practices.** AI-powered tools can assist teachers in lesson planning,

2 IDRC, "Building a Network of Excellence in Artificial Intelligence in Sub-Saharan Africa".

3 Schools ICT "What is Immersive Reader?"

curriculum development, and classroom management. These tools can provide teachers with access to a vast repository of educational resources, lesson plans, and teaching materials, saving them time and effort in preparing their lessons (Intelliverse AI, 2023).

- b. Administrative activities:** In dealing with administrative issues, machine learning can automate the delegation of duties, support complex decisions, design new solutions, and undertake complex task assignment, scheduling and planning techniques. Repetitive tasks such as enrolment, creating lesson plans, marking and grading students' tests can become automated, saving the time and energy of teachers for increased student contact (Onaolapo and Onifade, 2020; Ayoub, 2020; Bhatt, 2023; Adlawan, 2024).
- c. Marking and grading of tests:** Studies by (Makala, Schmitt & Caballero 2021; Ahmad et al. 2020; van der Vorst et al., 2019; Holmes & Tuomi, 2022) agree that AI can currently automate grading for nearly all kinds of multiple-choice and fill-in-the-blank testing. A teacher spends a tremendous amount of time grading homework and tests. AI can step in and make quick work out of these tasks while at the same time offering recommendations for how to close the gaps in learning. As AI steps in to automate admin tasks, it opens up more time for teachers to spend with each student. The learning efficiency is thus improved by frequent interaction between teachers and students.

Example of automated grading system in China

China recently experimented on a machine learning designed essay grading system, which graded the work of 60,000 schools for automatic essay correction, with a level of precision matching humans in 92% of the cases (UNESCO, 2019). Educators spend a lot of time and resources on administrative tasks, and innovations like this which can handle these tasks frees up time for the teacher to enable them focus on student guidance. Machine learning can therefore promote student success, improve retention, streamline enrolment, grade tests, and better manage resources in the African education sector.

2.1.4 Improving course contents

Study by (Ahmad et al., 2020; Gibson, 2023) shows that AI systems can use the materials of a traditional syllabus to create customized textbooks for certain subjects. Such systems digitize this course material and create new learning interfaces to help students of all academic grades and ages. They can make the content easily digestible by dividing it into understandable pieces, highlighting important lesson stuff, summarizing key points and more. And, they can even create audio and video content. Students can easily access all these materials, learn much faster and reach their academic goals.

2.1.5 Intelligent tutees

(Hwang et al., 2020; Bhatt, 2023) states that studies in this category are rarely seen since most AI-based educational systems generally focus on helping learners rather than providing opportunities to encourage learners to serve as a tutor or advisor. Nevertheless, engaging learners in the contexts of helping others (i.e., AI tutees) understand complex concepts could be an excellent approach to promoting their higher order thinking competences and knowledge levels. Although no studies have aimed to develop intelligent tutees intentionally and explicitly, many AI models and techniques are capable of learning the knowledge and experience from the interaction with humans. The learning ability of AI models and methods can facilitate the

development of intelligent tutees in the future.

2.1.6 Policy-making advisor

AI techniques have been employed to inform and guide development of policy or laws in the recent years (Hwang et al., 2022; Bhatt, 2023). Therefore, it is possible and feasible for African countries to develop a policy-making advisor for policy building in education. With the help of AI technologies, policymakers can more precisely understand the trends and problems in educational settings from both macro and micro perspectives, which can help them build and evaluate effective educational policies.

2.1.7 Improving quality of education

One of the major challenges in Africa is the lack of access to quality education, especially in remote and underserved areas. Several studies (Intelliverse AI, 2023; Nzoka, 2024) show that AI can help overcome this barrier by providing virtual classrooms and online education platforms. These platforms can deliver educational content to students who may not have access to traditional schools or qualified teachers. Through AI-powered virtual classrooms, students can engage in interactive learning experiences, access educational resources, and receive personalized instruction tailored to their individual needs.

AI can also help Africa solve the teacher shortage in order to improve the quality of Education. (Hooijdonk, 2019) agrees that while some believe that chatbots and other AI solutions will eventually take over our jobs, there's a labor shortage in education, so AI can actually help education institutions to overcome this challenge. Chen et al. (2020) notes that embedded systems have made it possible to use robots, in the form of cobots or humanoid robots as teacher colleagues or independent instructors, as well as chatbots to perform teacher or instructor-like functions. The use of these platforms and tools have enabled or improved teacher effectiveness and efficiency, resulting in improved instructional quality.

2.1.8 Collaborative learning

AI plays a role in collaborative learning environments. Virtual assistants and chatbots powered by AI facilitate communication and teamwork among students, promoting interactive discussions and group projects. AI promotes collaborative learning in situations where learners are not physically in the same location, with techniques such as shallow text processing (UNESCO, 2019; Rollins, 2023). This implies that African students residing in different African countries can collaborate and study together, without having to travel, thus providing crowdsourcing solutions. The brain drain challenge can also be handled as African intellectuals do not need to relocate to foreign nations to obtain standard education, as these courses can be handled online digitally from their resident location.

2.1.9 Accessible and inclusive education

Currently Africa still uses traditional education that does not serve everyone. Onaolapo and Onifade (2020) points out that AI has the capability to enrich teaching and learning experience in Africa, thus fostering the achievement of the Sustainable Development Goal 4. AI can make education more accessible and individualized, allowing instructors to provide students with a more personalized approach and encouraging learners to continue education. Further, AI in education will fill gaps as it will offer everyone the opportunity to become better educated in fields more suited to them.

(Ayoub, 2020; Intelliverse AI, 2023; Nzoka, 2024) states that AI can also help educators foster greater inclusivity. For example, through AI-based language translation, it can enable more students with diverse backgrounds to participate in a class or listen to a lecture. As stated by UNESCO (2019), AI technologies can also be used to ensure equitable and inclusive access to education to marginalized people and communities. Africans living in isolated communities can now be reached and provided access to appropriate learning opportunities.

According to UNESCO (2020) AI can be utilized to assist in refugee education by overcoming language barriers and helping to promote inclusive and equitable access to education. AI technologies have been also used to bridge gender divides and gaps in access for people with disabilities (Han et al, 2023). Intelligent Tutoring Systems are also part of the new technological possibilities to expand educational learning in Africa (Makala, Schmitt & Caballero, 2021; **Ndemo, 2019) emphasizes that** AI will change what we learn and how we teach and learn it; and in the process help to discover individual capabilities, enabling accessible and inclusive education with better utilization of educational resources in Africa.

2.1.10 Reduce the cost of education

Africa is facing significant challenges throughout its education system, such as high costs, low retention rates, poor study content, and untrained teachers. High university fees are a barrier to Africans' pursuit of a tertiary education, ultimately hindering overall growth of the continent. Africa can overcome most of these challenges through the use AI in form of Massive Online Open Courses (MOOCs)⁴.

MOOCs is an online mode of study that is characterized for being an online-delivered course of a specific subject, which is massive and available to users, that is, it is designed and implemented to be delivered to a large number of students at once, and generally free (Ocaña, Valenzuela, and Garro, 2019).

A key challenge to providing quality learning at scale is doing so at low cost. Increasing access to improved connectivity, coupled with online digital learning approaches such as massive open online courses (MOOCs), has improved the capacity to provide a large number of people with quality educational content and experiences. While early evidence on MOOCs shows that people with higher levels of education and socio-economic status tend to benefit disproportionately (Hansen & Reich 2015), some research illustrates those certain types of MOOCs – such as those offering job related training - can benefit users from low- and middle-income populations in the Global South (Garrido et al. 2016).

AI can also reduce the cost borne by educational institutes as it removes unnecessary work and automates processes which reduce the resource requirements (Adlawan, 2024). The reduced cost thus can be transferred to other stakeholders such as students.

AI aims to significantly reduce education costs everywhere, making it more feasible for developing countries and older students. This would be made possible by adopting virtual teaching, augmented virtual chatbots/agents and remote physical teachers (Matt, 2024).

4 Frost & Sullivan, Digital Education: South Africa's Economic Imperative

2.1.11 Reduce poverty and boost shared prosperity

Poverty is usually associated with the inability of households to have formal education. The World Bank estimates that about 39 per cent of the world poorest do not have formal education. Aspects that hinder access to education for many households is purely the cost factor and capacity of the institutions of higher learning. Many institutions have a prescribed number of people they can accommodate (Wong, 2020). AI can assist in raising the levels of education for the poor children in the various methods which include adapted learning techniques using computer algorithms to encourage interaction with the learner as well as coming up with an education that is tailor-made for the needs of each learner (DAIA, 2020).

For many, education represents and enables future growth and opportunity. Literacy in language, math and sciences, and other essential skills empower individuals to participate in today's global economy and perhaps break cycles of poverty. However, the United Nations reports that in low-income countries, Africa included, 91% of students in primary school fail to achieve minimum reading proficiency and 87% fail to achieve basic math proficiency. The application of AI in education sector has the potential to provide equal opportunities to all students worldwide, thereby investing in future innovation and global development (UNESCO, 2017). In the long run this can reduce poverty and boost shared prosperity in Africa.

2.1.12 Reduce the dropout rate in schools

(Macha, 2017) states that dropout rates across the African continent are high; this has significant consequences in terms of social and economic development, loss of opportunity to develop African talent, and the cost to academic institutions. AI can be used in Africa to predict dropouts and allow academic institutions to take adequate preventive measures. This will go along in reducing the dropout rates in African learning institutions.

AI can help prevent students from dropping out of school by examining early warning signs collected from AI. Teachers and administrators can then intervene with “at-risk students” before they quit school. Dropping out of school correlates with numerous factors including frequent absenteeism, poor test and project performance, incomplete homework, and a lack of participation in extracurricular activities. With educational data mining and perceptive analysis of data, school systems can intervene before drop outs occur⁵.

2.2 Impact of covid-19 on the digitalization of education in Kenya

The suspension of face-to-face learning through state-mandated closures due to the 2019 coronavirus disease (COVID-19) has led to a redefinition of teaching and learning approaches (Zhao & Watterston, 2021). The Covid-19 pandemic has clearly acted as a catalyst for digital transformation in education (UNICEF, 2020). In March 2020, approximately ninety percent of the global student population was affected by government-mandated school closures and other key sectors of the economy. The pandemic forced educational institutions to offer virtual teaching and learning as a substitute measure for national closures (Ofusori, 2021). The impact was worst in developing countries, as most failed to transition to digital teaching and learning. Digitalization of education in Kenya was affected both positively and negatively by Covid-19 crisis as shown below.

⁵ Source: www.thetechadvocate.org/using-artificial-intelligence-to-lower-high-school-dropout-rates/

2.2.1 Positive Impacts

- 1. Accelerated digital transformation in education:** COVID-19 has accelerated digital transformation in the education sector. Digital transformation has rejuvenated teaching and learning processes during Covid-19 pandemic. The tremendous adversities caused by Covid-19 has forced students and lecturers to use digital technologies in tackling learning adversities. For example, digital transformation has significantly affected higher education which eventually has led to creation of innovative learning opportunities. Virtual learning platforms such as Google Classroom, Google Meet, Zoom, Moodle, Microsoft class notes and Skype have been adopted in higher education by lecturers and students to enhance digital learning (Crawford et al., 2020). Digital transformation has offered the possibility to lecture as well as learn in innovative manner contrary to face-to-face classroom environment of teaching and learning (Pokhrel & Chhetri, 2021).
- 2. Positive changes in attitudes:** The pandemic brought about challenges to learning activities namely how to teach while at the same time keeping social distance. Hence, Covid-19 crisis made the evolution of digital transformation much quicker (Mladenova, Kalmukov & Valova, 2020). The COVID-19 pandemic prompted the utilization of digital services and resulted in positive changes in individuals' attitude of digital transformation in public sector (Shao et al., 2022). For example, in Kenya, the use of radios, TV, and internet-based platforms such as YouTube, Kenya Education Cloud, zoom, blue jeans, WhatsApp, and Google Classrooms among others have shown that learning and teaching can take place effectively anywhere through distant learning platforms provided that enabling infrastructure is available. Much of these distance learning platforms have been in use in the Kenyan education system but the COVID-19 pandemic led to their scaled utilization (Government of Kenya, 2020).
- 3. Increased digital literacy by learners and teachers:** COVID-19 has pushed forward the agenda on digital literacy and embracing of technology. Those schools and teachers who were reluctant to train and move into new pedagogical approaches have had no choice faced with the new norm of online instruction (Mbii, Koskei & Kyalo, 2020). (Osabwa, 2022) points out that both faculty and students will develop a major interest in digital literacy, given the necessity of such knowledge and skills. The social distancing health protocols necessitated by COVID-19 have intensified dissemination of information concerning online education solutions, some that were hitherto unknown to Africa. There is a likelihood that faculty and students will be curious to know more, lest they get disadvantaged again.
- 4. Mainstreaming blended learning:** Study by (Osabwa, 2022) concludes that it is highly unlikely that Africa, despite its technological downsides, will revert to purely face-to-face modes of teaching and learning. The least that will be expected is the blended mode, so that the new normal will be characterized by a sustained focus on the huge demand of, and challenges around virtual teaching and learning, with access to and quality of online education being central. (Venkat, 2022) notes that COVID-19 forced all institutions to move online almost overnight irrespective of their prior beliefs about online education. Even though the immediate online shift has largely been a 'lift and shift' of materials and instruction, many teachers have been forced to use a variety of digital tools online which they were not familiar with before. As they experience these tools, we can envision they will want to modify pedagogy and materials to leverage the capabilities offered by these tools. Besides, the emerging consensus seems to be that the future is likely to be a

blended model in most institutions. As a result, we can expect to see further changes in the role of the teacher in the future.

5. **Reducing fears and resistance:** According to (The Mastercard, 2023) report the pandemic provides a powerful use-case for the more intentional integration of technology into education systems. Technology has diverse applications in the education sector, from digitizing course materials and teaching aides to remote tutoring, to more advanced tailored learning that provides rapid assessment and feedback. Necessity has removed some of the fear and resistance to the integration of technology in education systems. Post-pandemic, there will be much to learn about what did and didn't work, such as the important role of the teacher in facilitating distance learning and maintaining a personalized connection with students and inequities in access due to enabling infrastructure such as Internet connectivity and electricity, access to devices and digital literacy. However, as with many other fields such as health care and e-commerce, the changes brought about by the pandemic are likely to alter the education system permanently.

2.2.2 Negative Impact

1. **Psychological agony:** In the time of COVID-19 crisis, (Almaiah, Al-Khasawneh & Althunibat, 2020) noted that numerous problems were encountered which affected the higher education learning preparedness to implement online teaching. The hindrances were working under duress, availability of technical personnel and reliability on digital technology processes and e-learning tools (Ebner et al., 2020). The digital transformation in higher educations during COVID-19 led to psychological agony, and depression amongst students who favored physical classroom learning.
2. **Access to technologies:** In developing nations, Kenya included, the economically disadvantaged learners could not afford digital devices making it difficult to take part in e-learning classes (Sintema, 2020).
3. **Health risks:** Again also, the online sessions create healthy risks due to prolonged screen time for the students (Sintema, 2020)
4. **Limited consultations:** Weak students face challenges since they need maximum supervision. (Sintema, 2020) indicated that the academic performances dropped due to reduced contact between students and lecturers and inadequate consultation with lecturers when faced with e-learning challenges.
5. **Online assessments:** Learner assessments were carried out digitally which attracted doubts and indecision amongst lecturers, learners and the guardians. Online teaching has socio-economic as well as psychological consequences on the learners wellbeing (Doucet et al., 2020).
6. **Inadequate digital preparedness:** Study by (Okumu & Nyabundi, 2023) concluded that COVID-19 pandemic uncovered the lack of preparation of many higher education institutions in Kenya in terms of digital transformation. This study shows various challenges lecturers experienced when using technologies to teach. The study revealed that higher learning institutions in Kenya had developed very little regardless of the variety of universities offering virtual studies. Specific challenges identified included: how to arrange online classes, how to carry out online teaching according to the plan, which online teaching platform to choose, and how to monitor the effect and quality of

online teaching, which will lead to a decrease in user satisfaction. Another research by (Nganga, Waruru, & Nakweya, 2020) indicates that teaching staff who had undertaken professional development in online and blended learning were much better prepared for the move online, and had a much more positive experience. Where they had not, and universities had not invested in infrastructure to support online teaching, things were more difficult. For example, there was uneven success at maintaining a 'semblance of normality' across universities in Kenya.

7. **Private institutions were better prepared:** According to (Human Rights Watch 2020) private schools were relatively better prepared and equipped for distance learning, given greater access to digital technology. Despite private schools undertaking the prescribed education curriculum and programmes of the Kenya Institute of Curriculum Development (KICD) (designed for continued learning during cessation of face-to-face learning), which adopted existing technology-based remote teaching and learning approaches, little progress and success was recorded, as teachers were not adequately prepared and requisite technological competencies were lacking.
8. **Internet connectivity and power:** (Osabwa, 2022) points out that generally, Kenya was not ready to facilitate online education as exemplified by its low internet connectivity as well as poor electrical infrastructure. There were many parts of the country where mobile network connectivity was erratic, and where it existed, the signal was weak. This was quite discouraging, since one could not access the internet even if they had the know-how and requisite devices. Furthermore, the intermittent supply of electricity, at least in areas that had been connected to the national grid, worsened the bad situation. Teachers and Lecturers who resided in the disadvantaged regions could not access the internet. Hence were both helpless, and unhelpful to students. COVID-19 wreaked havoc across the world. Nonetheless, it reminded the education players in Kenyan universities, and African ones in general, on the need to be ready for any eventuality.
9. **Educational inequalities due to the digital divide:** The pandemic forced learners and teachers out of school in an unprecedented manner (Onyema et al., 2020), presumably to continue to engage remotely with a transition from the traditional brick-and-mortar classrooms to the virtual space. The pandemic brought a new reality that necessitates a rethink of how quality education can be effectively delivered in an inclusive and equitable manner using technology. For example:
 - a. (Ngwacho, 2020) study findings revealed that with the government adopting remote teaching to support distance learning and online education delivered through radio and television and internet, learners from poor, vulnerable and marginalized household had no access to these mediums of learning further worsening inequality in access and quality of education.
 - b. Similarly, (Bett, 2021) notes that children with limited learning support at home had no means to support their education as other capable institutions adopted remote and digital mode of learning thus created a wide gap in education equity. COVID-19 widened this digital gap between people who have sufficient knowledge and resources to access technology and those who do not, thereby perpetuating worse education inequity.
 - c. (Malenya & Ohba, 2023) points out that in Kenya, the existing digital divide on the part of the learners and schools served to reproduce or even widen inequities in learning. The COVID-19 pandemic evidently made these inequities more visible or even worse.

What had been conceived as and intended to be an equitable and inclusive learning exercise ended up marginalising learners in already marginalised spaces.

- d. (Mbii, Koskei & Kyalo, 2020) also reported that the digital learning has created more inequality among the learners due to inaccessibility by the majority during the pandemic. Many teachers and learners did not have knowledge and skills to use online platform for learning (Kisirko & Kamanga, 2022). The catastrophe revealed the reality of the deep digital divide and associated equity gaps which need critical attention (World Bank, 2020).

2.3 Success stories

2.3.1 Eneza Education

Eneza Education is a comprehensive virtual tutor providing universal access to affordable, quality, lifelong learning through mobile technology. It was founded in 2011 and launched in Kenya in 2013. It has since then to Ghana in 2017, Ivory Coast in 2018 and Rwanda in 2021. The key features of Eneza Education are given here below:

1. **Educational problems being addressed:** The mobile learning platform helps tackle Africa's problems of illiteracy, school dropouts, high textbook costs and lack of quality feedback for learners.
2. **Services:** Offers learning and revision materials to primary and secondary learners on any device; provides virtual educational instructions; and Connect learners with virtual teachers
3. **How Eneza education works:** Once registered on the platform, students choose a topic to study. Questions are sent to them by SMS, in the form of a quiz at the end of which they can see their results and work on another topic, after suggestions from the teaching staff. If a student does not perform satisfactorily on the test, Eneza Education sends short lessons on the subject for the student to fill in the gaps. In addition, students can use the "Ask a Teacher" service, which allows questions to be sent by SMS to a group of teachers who respond in less than five minutes on average
4. **Key advantages.** It offers the following advantages
 - a. The solution does not require the acquisition of particularly expensive computer and technological equipment such as smartphones. A simple phone connected to the telephone network is enough to receive lessons by SMS.
 - b. For a school, offering a service similar to "Ask and Teacher" could be particularly beneficial as it would allow, for example, to accompany students in the completion of homework. For many reasons, students are not equal in the amount of support they get from their family circle. The school institution could partly remedy this by offering this service and by encouraging the commitment and motivation of its students in their learning.

▶ Achievements so far

It has reached six million plus learners since its inception, 70% of whom are in rural areas and Eneza is Africa's number one mobile learning platform for learners ages 10 to 25-years-old.

▶ Shortcoming:

The solution has the following shortcomings:

- a. It's success depends on the level of mobile phone penetrations of a region. This means the solution may not be effective in Africa countries that currently have low mobile phone penetration and internet access.
- b. It is SMS based, which is becoming increasing obsolete, especially amongst young people who prefers WhatsApp, Facebook etc.

2.3.2 M-Shule

M-Shule startup was launched in 2016 in Kenya by two entrepreneurs - Claire Mongeau and Julie Otieno. M-Shule is an AI/SMS platform that analyzes the student progress and performance and provides personalized learning content to the user according to their abilities. M-Shule – “Mobile School” – is the first adaptive mobile learning platform in Africa which connects primary school students with personalized tutoring and assessments.

▶ Problem solved by M-Shule

Parents and schools across Sub-Saharan Africa want to invest in their students' learning. Even beyond school fees, the market for supplementary education tools like tutors, extra materials, and help outside of class is \$2.5 billion or more across the continent. But still primary students are falling behind – less than 10% of students that enroll in primary school will make it to university (Brookings Institute). Standard content in the classroom and in external tools doesn't address every student's learning needs; learning communities need access to personalized, quality tools to reverse learning trends.

M-Shule is an SMS and web-based learning management platform which makes use of artificial intelligence to design tailored learning experiences. It was designed to handle 144 million primary school students across Sub-Saharan Africa. M-Shule currently operate in Kenya but they intended to expand into East Africa and throughout Sub-Saharan Africa and South Asia in subsequent years. The organization, based in Nairobi (Kenya), has won several top awards and gained recognition in the last two years for its drive to improve the level of education especially for primary school learners who come from low-income areas.

▶ How M-Shule works:

- a. M-Shule's platform uses artificial intelligence to provide personalised learning support in Maths and English via SMS and chatbots. The system uses each student's learning data to create and deliver the most relevant learning content for them in the form of SMS-based lessons, tailored to each pupil's strengths. M-Shule then shares performance data and results with parents, schools and organisations to empower the whole learning community, delivering high quality learning for each child. M-Shule is Africa's first mobile learning platform to build skills and education through AI and SMS. It is designed to improve performance for 144 million primary school students across Kenya and Sub-Saharan Africa.

The programme is SMS based, which makes it potentially accessible to the 456 million mobile phone users on the continent.

- b.** M-Shule creates hundreds of personalised mini-lessons in Maths and English. These lessons are delivered via the SMS interface, and children can access it either via their phone or their parents. M-Shule then analyses their performance and shares it with their teachers or parents – giving them community support where they need it.
- c.** The platform’s adaptive learning engine continuously analyzes each learner’s ability in order to generate personalized learning tracks and build their skills. Its adaptive learning engine uses artificial intelligence to create tailored SMS lessons based on each individual child’s competence. Following flexible learning pathways, lessons delivered are harder or easier, depending on the answers provided by students. Their progress and proficiency profile are updated and the data is used for reports on their performance. It provides an integrated solution - easily accessible through SMS for parents and teachers, with a web app for school directors.
- d.** M-Shule focuses on the provision of accessible education to impact lower-income communities. The team recognized that parents and learners are not getting the right support for education due to a lack of sufficient resources and technical knowledge, as well as the lack of access to information and communication technology. They wanted to utilize existing technologies such as mobile phones, both smartphones and feature phones, to be able to reach communities without the requirement for additional resources and identified the use of SMS technologies to be the most efficient approach.
- e.** Content is produced with educators as well as content publishers to ensure both localization and relevance of content to the targeted learners. The material was produced in bite-size pieces and is capable of adapting to the different levels of the learners based on their interaction and responses with the content. The content is delivered via SMS, and M-Schule works with local telecommunications companies to push out material at no cost to the learner. Usually, the school pays for the cost of SMS technology and students can interact with the material with no additional cost. In situations where learners are accessing the technology independent of school service, the cost of accessing the technology is between 1 USD or 2 USD for three months of access.

► Advantages of M-Shule

M-Shule relies on local tech strengths: most Kenyans own or have access to at least a basic mobile phone, and use SMS already for communication and money transfers. By leveraging these existing tools and habits, M-Shule has been able to provide an affordable, personalised learning aid that has the potential to improve access to education, improve student learning, and build community, at a profit.

Results

- More than 10,000 learners in Nairobi in less than 2 years.
- 100% of students reported improving in performance and confidence.
- 85% of parents reported that M-Shule's feedback helped them better support their child
- 85% of parents and students reported an improvement in scores SMS learning for out-of-school learners Our SMS tuition platform provides Maths and English revision over SMS for primary school students, on any phone.
- Currently, all primary learners in Kenya may register and learn for at least 2 weeks for free while at home.

2.3.3 SmartClass - Tanzania

▶ Introducing smartClass

Launched in Tanzania in 2019, SmartClass is an online platform that leverages big data and artificial intelligence to match students to qualified and certified tutors based on their learning needs. SmartClass enables face-to-face tutoring or online, either one-on-one or in groups. Through the platform, a pool of teachers who have been interviewed and thoroughly vetted offer their services to learners, providing a source of income for tutors while improving the education of Tanzania's students. SmartClass tutors work with students aged 4 to 18 years old (K-12 learners) as well as 18 to 40 old with a focus on academics, agriculture, information technology (IT), business, exams preparations, language learning, vocational education, dance, and music.

The platform was a result of intensive research that found most parents struggle to get qualified tutors to teach their children various subjects - especially primary and secondary subjects. To ensure the authenticity and qualifications of a tutor, the platform connects to other educational institutions to help to verify their information. AI technology helps to measure the qualifications of the tutors since certificates of every tutor cannot be verified physically. There is a database connected with The National Examination Council of Tanzania (NECTA), and University of Dar es Salaam, so this AI helps to verify the information.

The platform, under incubation at the University of Dar es Salaam, provides an opportunity for qualified tutors to sell their skills for a minimum of 3,000 Tanzanian Shillings (1.30 United States Dollars) per hour. It has already attracted 5,000 tutors and 7,000 students since it started operating.

Smartclass which is freely accessible through registration as a tutor or student, is changing the learning environment in Tanzania. With many citizens now on their smartphones, tutors can more easily sell their skills and make a living, and students can literally become smarter by using their phones.

▶ How SmartClass work

SmartClass uses computer algorithms and artificial intelligence to match students to low-cost qualified, certified, and vetted tutors based on their learning needs. SmartClass also enables face-to-face tutoring, either one-on-one or in groups. Due to the low levels of internet access in Tanzania, SmartClass has developed an offline option where learners can request for the nearest tutor via SMS.

Through the platform, www.smartclasstz.com and www.smartclass.co.ke for Tanzania and Kenya respectively, a pool of teachers who have been interviewed and thoroughly vetted offer their services to learners, providing a source of income to low- and middle-income tutors while improving education for students.

SmartClass tutors work with students aged between four and 18 years old (K–12 learners) with a focus on academics, IT, exam preparations, language learning, vocational education, dance, and music.

► Impact of SmartClass

In the first year, SmartClass achieved a great deal, becoming a leading platform for Tanzanians to book qualified and certified tutors both online and offline. Over the past year, SmartClass has helped boost education in Tanzania. Its prime goal is to collaboratively work with the government and other educational players to provide access to quality education for all Tanzanians. The performance in mathematics, sciences, and English of more than 10,000 SmartClass-registered students has improved by more than 50 per cent. Parents are also happy to see their children tutored in the safety of their homes.

SmartClass's educational model ensures no one is left behind in learning. Together with the Tanzanian government, other educational players, and advanced technologies, they are building up an inclusive educational model that allows anyone to learn anything, anytime, anywhere. An inclusive educational model that offers quality education means a better future for everyone.

SmartClass aims to break through barriers to learning, enhance learning methods to improve students' outcomes and results, as well as drive efficacy in learning through live interactions. They believe that the most effective way to learn is through personalised learning experiences. Analytics and advanced algorithms match students with best-suited tutors. Their business model also allows SmartClass to subsidise underprivileged students. So far, they have subsidised more than 2,000 students. They do this by allowing students to form a group of up to 10 students, book a tutor and share the fee.

► Jobs or opportunities created by SmartClass

SmartClass has generated new jobs for more than 5,000 active registered tutors. The tutors earn a passive income of \$240 per month on average. This has substantially improved the standard of living of the tutors and their families. Currently, SmartClass is a home of more than 3000 active qualified and certified tutors and over 2000 active students who use SmartClass to learn subjects like mathematics, science, English, and programming. SmartClass has seen many private tutors growing their income while helping students to achieve their educational goals. For the year 2019, SmartClass won a seed fund of \$5,000 from the Tony Elumelu Foundation. SmartClass was selected as one of the promising future businesses across Africa. In 2020, SmartClass launched SmartClass Kenya. There is high demand for private tutoring in Kenya and at 89.7 per cent, internet access is good. SmartClass aims to support as many learners as possible to achieve their own learning goals. It targets to attract more than one million tutors in Africa who will be teaching more than 500 subjects.

2.3.4 Daptio – South Africa

Founded in 2013 and based in Cape Town, Daptio uses artificial intelligence to help students, mentors and teachers to understand the proficiency level of each student as well as match the

relevant content. The goal is to find a model that allows students to receive the right content, leading to a more tailored education and higher grades. Daptio delivers suitable teachers and content via AI technologies. Daptio is an adaptive learning platform that makes use of artificial intelligence to help students study remotely. It specializes in courses whose content, structure, and assessments are designed to adjust based on the strengths and weaknesses of the students.

Daptio enables underserved communities to “move away from the current one size fits all education model that is failing. Daptio’s key local competitors are Get Smarter, Funda and ReThink Education. While Daptio has several local competitors, its unique selling point is its mobile first solution. Daptio is built uniquely, aiming to help ease the local challenges. The mobile-first platform provides content broken into chunks with small sizes to ease consumption and reduce data usage as well.

This is an important element in a country where far more learners have access to mobile phones than larger mobile devices such as tablets and laptops. Daptio promises ‘granular analytics’ that give teachers detailed breakdowns of individual student performance. This data can then be used to improve student outcomes.

Daptio improves adaptive learning by collecting learner data on an individual level to support a model that gives students key content at just the right time ultimately leading to higher understanding and better grades. Daptio leverages the power of student smartphones to send small amounts of data to their teachers—these individual data points aggregate to create a holistic learning profile. Teachers can then use this granular level of information to provide vital learning analytics such as student preferences and progress. As teachers use this data to improve their curriculum and pedagogy, they promote higher student engagement to create a virtuous learning circle.

Daptio is the first content agnostic adaptive learning platform. This means that it is compatible with many types of platforms or operating systems. Hence, content providers and teachers can now create online content that is able to adapt to the specific needs of every user in a class. It uses artificial intelligence to learn about both the user and the content as students work through it, and can thus adapt the theory and the difficulty level of questions to suit the needs of every learner.

The platform is largely structured on video learning, with individual sections for students, teachers and content creators. It also adapts to students who do not have access to stable data connectivity to watch videos. The software consists of three main parts: the student, teacher and content creator dashboards. These dashboards are then installed or implemented into an existing piece of software for which a licensing fee will be charged for content publishers. Student data is then used to encourage improvement or focus on relevant areas of content.

Daptio offers videos as links, for instance, so students on phones have the option to watch them later on different devices or areas with better data connectivity. Daptio is also built to fit into whatever technology the client currently uses, from a plain website to full learning management system, ensuring that many potential competitors become key clients.

As opposed to the restrictive, traditional approach of providing content to students based on their grade level, Daptio leverages cloud-based technology and AI to match students’ aptitude levels, enabling them to learn at their own pace. AI education providers like Daptio support

students and other education stakeholders, especially those in emerging markets, in acquiring and perfecting the knowledge and skills that young people need to enter the job market successfully. Daptio recently scooped top honours at the Telkom Open Innovation Mega Challenge and has also been named one of the top 10 most innovative companies in Africa. Daptio offers a software as a service platform to publishers and content creators to create adaptive online courses. It claims that the content, assessments and course structure adapts to a student's strengths and weaknesses. The courses can be embedded in the client's site, portal or LMS. The interface is designed for mobile devices and optimized for slower low-end devices and poor connections. Winner of the 2014 Telkom Innovation Mega Challenge, and was named one of the top 10 most innovative companies in Africa by the Fast Company.

2.3.5 Gradely - Nigeria

Nigerian ed-tech startup Gradely is a homegrown, virtual learning management system (LMS) for schools. Founded in 2019 Gradely uses AI to help parents and schools intervene in real-time to children's learning gaps. Gradely is a platform that empowers schools to quickly identify gaps in their students' learning and supports parents to plug them before it is too late, so you can take charge of their progress and help them succeed in school and in life. Through weekly adaptive homework tests taken on the web or mobile device, Gradely is able to tell how much of a topic a student understands and recommend specific practice sets, remedial videos or private tutoring.⁶

The startup launched its LMS, known as "Gradely for Schools". It is a teacher-led LMS, built for personalised learning, with features such as live classes to organise and hold engaging class experiences, assessment tools to set up robust and relevant assessment formats fitted with the Nigerian and British curriculum-aligned question pool, a proctored examination system to hold credible remote academic evaluations, and a suite of personalised video lessons, practice quizzes and games library known as Gradely CatchUp! to support in-class efforts with students at home.

Gradely is Africa's first truly personalised learning platform that empowers educators and parents to make positive impact and difference in their children's learning journeys and produce more globally-competitive learners and resilient leaders. The personalisation works by having tonnes of assessment content mapped by topic and difficulty, and following performance on adaptive tests, students are provided recommendations daily to catch up on weak areas. This leads to measurable improvement in student's performance and a learning path that is unique to each child.

It is possible to use Gradely at home as a standalone learning supplement or in conjunction with school, so that homework and class material can be viewed directly on the app as well. In this case, where the app is school-integrated, parents see a report that is the most representative source of truth of the child's learning progress.

Gradely was launched first in Nigeria but plans to expand region-by-region across Africa and potentially globally as the use-cases for a content-driven personalised learning platform are very scalable. So far, Gradely has been used by over 5,000 Nigerian parents and 200 schools as part of its beta testing, and it is now planning a wider rollout.

⁶ <https://gradely.ng/>

As internet penetration and device access accelerates, however, Gradely believes every school and parent in Africa will require a digital learning environment that complements classroom education and gives students a leg up in future exams. Gradely is such a solution, and charges schools an annual per student fee for LMS access and an additional fee for content access. It also charges parents a monthly subscription for content access as well as fees per live tutor session.

▶ How Gradely Works

Gradely works as follows:

1. **For students and parents:** the students take homework and practice; the system recommends relevant exercises based on student's learning skills and levels on a daily basis; the parents can get real-time feedback on learning progress. Charges are \$5 per month on content subscription (practice and video lessons), and \$7 per on-demand tutor sessions.
2. **For schools:** they just need to set up classes, use AI-assisted assessment, and view students' reports. Charges are \$15 subscription per student per year and \$50 for the premium subscription. Schools use the app primarily to create assessments and recommend existing lessons to students, but they can also use it to create lessons, run live classes and manage their schools digitally, including by holding remedial video-conferencing classes, and automatically report class and student progress. These reports show topic-level strengths and weaknesses per child.

▶ AI impact on Gradely

How the AI works is that every day the app recommends practice questions or animated video lessons as well as real-time online tutors that are matched to students based on learning areas where they need to catch up. As a student clears a level of mastery, the app keeps automatically stringing practice questions of increasing difficulty until they achieve 100% mastery. Over time, Gradely startup expects to have enough data to compare kids state-wide or nationally, predict class and national exam scores, measure teacher or tutor impact on learning, help schools make better decisions about teacher training material or teacher hiring, and finally, help parents make better decisions on tutors or schools that match their child(ren)'s learning process.

▶ Filling learning gaps

The potential impact of a solution like this, at scale, is huge. According to the UN's World Development Report, nine out of ten students in Africa are in school, but not learning. Around half of 1.5 million secondary school students fail prerequisite subjects like Maths and English in exit exams every year, meaning the majority of school-leaving children fail to get university-qualifying grades. One of the reasons for this failure is that schools, parents, and teachers are unable to successfully catch and remedy learning gaps when they first surface; and because there is such a dense curriculum to comb through, students move to new topics, school terms and class years without enough opportunity to remedy learning gaps.

Gradely looks to fix this and is taking advantage of the boost given to ed-tech solutions by the pandemic. Being locally based, meanwhile, might give it an edge in terms of securing a big enough share of the Nigerian education space. This is because many of its competitors are

either international parent-focused apps that are neither localized nor curriculum-aligned; or international school-focused apps like Google Classroom and Microsoft Teams that suffer for the same reasons.

▶ Expanding horizons

Currently operational in Lagos, it plans to scale across Africa and Europe – in countries like Ghana, South Africa and the UK – within the next two to three years.



2.4 Perceived and real negative impacts of AI in education

Despite all the positive impacts that AI can offer to Africa, there are some drawbacks of AI in education that are not directly linked with the limitations of the AI algorithms but to their negative impact on the society. Some of these negative impacts are explained below.

2.4.1 Job losses

Many are concerned that AI will eliminate jobs, worsen inequality, or erode incomes. Many studies have been conducted to examine this issue. While most do find that some jobs will disappear, many more will be transformed into jobs that require different skill sets, while other entirely new jobs will be created. Many jobs will continue to require uniquely human skills that AI and machines cannot replicate, such as creativity, collaboration, abstract and systems thinking, complex communication, and the ability to work in diverse environments.

Throughout history, the emergence of new technologies has been accompanied by warnings about human redundancy. However, in reality new technologies have created millions of more specialized, meaningful and skilled jobs⁷. Consistently over time, technology has proved to be “a great job-creating machine”⁸. Major, transformative technologies, as AI will prove to be, are capable of building entirely new sectors of the economy. Some of the new areas of economic opportunity and categories of employment will obviously be high technologies jobs closely linked to the creation, implementation, and maintenance of AI-based applications, including in software development, networking, and cyber security.

One of the existing biggest unsolved issues in education is shortage of teachers to the extent that 33 countries currently have insufficient teachers to provide every child with primary education even without a hope of solution by 2030 (UNESCO, 2019). To solve this issue, at least 25.8 million schools across the world are in need in order to achieve this goal. Since this seems impossible another suggested solution was AIED where an AI adaptive learning platform can be used for one teacher to effectively teach thousands of students at once. Even though this may be true, there is fear of losing job for many teachers despite the view of UNESCO (2019).

Emerging technology in the form of artificial intelligence and machine learning is beginning to alter education tools and institutions and changing what the future might look like in education. It is expected that artificial intelligence in U.S. education will grow by 47.5% from 2017-2021 according to the Artificial Intelligence Market in the US Education Sector report. Even though most experts believe the critical presence of teachers is irreplaceable, there will be many

7 Microsoft, The Future Computed, p. 92

8 Technology and People: The Great Job-Creating Machine, Deloitte.

changes to a teacher's job and to educational best practices.

There is a risk that teachers may need new skills to use AI responsibly. Currently, data-driven education is not part of teacher training, while AI does expect the user to have at least basic digital skills. If teachers cannot keep up with this development, there is a chance that the teacher of the future will be a data scientist with a less strong educational background. However, the risk that 'the teacher' will be automated is very small. If AI is to be able to take over all the tasks from a teacher, a form of Artificial General Intelligence is required, which we have found to be unrealistic in the near future (Grace et al. 2018).

AI advocates often argue that they are not trying to replace teachers but to make their life easier or more efficient. This should be viewed cautiously. The key driver of AI applications is cost-reduction, which means reducing the number of teachers, as this is the main cost in education (Ford, 2018).

However, (Diamandis & Kotler, 2020) reminds us that "productivity is the main reason companies want to automate workforces. Yet, time and again, the largest increases in productivity don't come from replacing humans with machines, but rather from augmenting machines with humans." Furthermore, Klutka et al. (2018) claim that AI can cope with many of the routine functions currently undertaken by instructors and administrators, freeing them up to solve more complex problems and to connect with students on deeper levels. This reinforces the view that the role of the instructor or teacher needs to move away from content presentation, content management and testing of content comprehension – all of which can be done by computing – towards skills development. Used in this way, AI supports teachers and instructors, but does not replace them. Perhaps the less welcome news for some is that many teachers and instructors will need to change the way they teach or they will become redundant.

The main arguments that have always been put forth in debates among scholars (Wogu et al., 2018) on the role and relevance of AI in the education sector, is the fact that, the introduction of intelligent grading systems/software could largely take away the burden of assessing and grading scripts from teachers, thereby giving them adequate time to concentrate on helping students mold their behaviour, things that teachers normally cannot do as a result of the pressure from other assignments, a task that machines cannot perform.

There is also the issue of AI being able to take over careers in academia like administration tasks and some tutoring jobs leading to career loss, hence the need for retraining. However, there are other group of scholars who argue that with the rising degree of automation going on in every sector of human endeavor, especially with jobs that are routine-like in nature, several studies have been conducted by scholars (Holmes, 2018) to substantiate the claims that the massive adoption of AI technology into all spheres of life, is unfavorable to the jobs of the workers who fall into this category. There are many other jobs that function to complement schools, but are services provided broadly across many industries; these jobs are very vulnerable to automation pressures. These include Jobs like bus drivers, cooks, security guards, janitors, secretaries, receptionists, accounting and reporting clerks. This means that tomorrow's schools will hire far fewer support staff to complement the school's mission to educate the nation's young people (Hansen, 2016).

(Haseski, 2019) found out that pre-service teachers felt that artificial intelligence could have both positive and negative effects on education. In this context, pre-service teachers stated that artificial intelligence could have positive effects on instruction, teachers, learning,

students and education.

On the other hand, pre-service teachers considered that the most significant negative effect of artificial intelligence on education was the possible destruction of the teaching profession. It can be argued that the idea that artificial intelligence could perform human jobs and thereby destroy certain professions, leading to unemployment. (McClure, 2018) supported the concerns of pre-service teachers on this issue. On the other hand, it was also reported that advanced technologies and artificial intelligence could not replace the teachers, however it may lead to the transformation of the profession (Popenici & Kerr, 2017).

Further, Ahmad et al. (2020) argues that similar to other sectors, deployment of AI in education at large scale will reduce the workload significantly, which may result in joblessness. AI could be deployed at different tasks in education, such as administrative tasks, teaching and security. Deployment of technology in these tasks may significantly reduce human labor. However, other researchers (Ndemo, 2019) believe that while AI has made significant advancements in education, there is no fear that human teachers can or will ever be replaced. As AI advances, it is more likely that it will provide support to teachers rather than replace them. Teaching remains a complex social interaction that requires authentic human skills, such as empathy for example, and these skills could hardly be learned by a machine. This means teachers will not ever be replaced by robots, but instead be assisted by them, becoming better at their fundamental job.

2.4.2 Increases the cost of power

Incorporating AI in education results in more consumption of power which will ultimately increase schools' budgets.

2.4.3 Isolation and individualization

(Ahmad et al., 2020; Nzoka, 2024) states that AI in education may lead to isolation and individualization instead of collective learning and teaching. One of the profound impacts of the growing adoption of AI systems in the education sector, is that it increases and promotes the learner's inability to study or learn independently off online platforms or via other mediums such as the Artificial Teacher Assistance (ATA) as students have become accustomed to AI embedded search engines at the tap of their fingertips or even AI generated responses/ essays/homework (Wogu et al., 2018). Such situations expose learners to certain psychological, social and emotional challenges which makes it difficult for them to mix with other students in a natural society. Studies reveal that most learners who use these online mediums, tend to miss out in their ability to develop critical 21st century problem solving skills (Ayodele et al., 2018).

2.4.4 Technology addiction

This is one of the foremost challenges associated with the massive adoption of IA technology as the only viable mode for acquiring and transmitting any form of knowledge amongst 21st century learners. Deploying AI at school level may results in kids' addiction to technology, such as phones and tablets, which may harm their health and personalities. The use of technology in learning also limits interaction with fellows and teachers which may result in isolation. Moreover, the deployment of AI in education may also result in students' dependency on machines to solve every problem that may risk their creativity and problem-solving capabilities. Learners affected by this factor find it difficult to replicate very essential models

of behaviour from their esteemed teachers/tutors (Watkins, 2017). (Hanna, 2020) research shows that too much technology use can lead to stress in the brains of children. This leads to cortisol releases that kill the cells of the memory. The presence of this factor is unfavorable to youths who already have psychological problems.

2.4.5 Inclusion and ease of accessibility

According to (Awofiranye, 2024) deployment of AI in education will increase dependence on the expensive technology that might deprive the poor of quality education. This can lead to an issue of inclusion and ease of accessibility. This is because many individuals do not have equal access to technology which can create a disadvantageous position for such individuals. For example, many students in developing countries do not have access to a smartphone or internet connection which can put them in a disadvantageous position compared to those who have such facilities. Besides the socio-economic status of students, geographical location can also be a factor in access to AI-based education.

2.4.6 Privacy issues

The use of AI in education raises questions about data privacy. Student data must be protected and used responsibly to ensure that students are not unfairly targeted or discriminated against based on their personal information. According to Ahmad et al. (2020) while AI can offer promising solutions in many fields including education, many ethical considerations can arise and cause limitations. Developing AI algorithms for education with ethical considerations in mind is challenging due primarily to the different definitions of what's and what isn't ethical in education. Also, it is critical to prevent using AI leading to serious biases when it comes to analyzing data and identifying patterns. In the area of privacy, when our data are left to machines to analyze and detect patterns, this is by itself can lead to serious privacy implications. For example, having access to students' online search behaviors can lead to detecting personal issues which can negatively lead to long term impacts.

The use of AI in education raises legitimate concerns about how educational data, like other intimate personal data, are gathered and used. What are the risks that a student's longitudinal performance data, intended for teachers to improve instruction, become public, or that poorly performing students are denied educational and employment opportunities? The challenge of who takes the responsibility of the data, who accesses the data and what level of data can be accessed without infringing on individual privacy has become a concern. As data is generated in different formats and sources, and across borders using the internet as a transporting means, individual privacy level becomes an issue. Ethical issues as relates to data usages and sharing cannot be monitored as responsibilities cannot be determined by instructions. (Ahmad et al., 2020) notes that increasing dependence on AI will lead to serious privacy concerns.

(Akgun & Greenhow, 2022) points out that AI is a privacy challenge because students must interact with the AI-based system which can limit their privacy through aspects such as facial recognition and recommender system. Student privacy can also be compromised if data captured by AI-based education systems lands in the wrong hands such as hackers.

2.4.7 Security concerns

(Ahmad et al., 2020) notes that AI is very dependent on data. Data in the education field are miscellaneous. Designing AI algorithms while security is very prominent and in mind is critical.

This requires distinguishing between sensitive and insensitive data before jumping to apply AI techniques on educational data. Hence, researchers are in need to develop intelligent AI techniques that are ready to deal with data in classified and careful ways.

While AI offers enormous benefits to teaching and learning, its proper functioning relies on the collection and analysis of personal data of students and faculty members in educational programmes. The collection of such confidential information raises serious issues of privacy and data protection. Safety and security issues regarding AI-based systems revolve around concepts such as safe AI for use by humans, verification, validation, self-awareness in adversary-prone environments⁹.

(Zawacki-Richter et al, 2019) notes that as AI systems becomes more integrated into teaching and learning, participants of educational programmes will be more exposed to unintended risks as other people could gain unauthorized access to their otherwise private lives, among other potential problems. Furthermore, since AI relies on data, its outcome and subsequent use are as good as the data put into it. Where the given data provides for a chance of having a misleading outcome, there is a high chance that AI could bring about serious problems to that effect¹⁰.

(Vincent-Lancrin & Vlies, 2020) states that Societies and individuals can benefit from AI innovations. They can have a positive impact on education and learning outcomes, and prepare students for a digital future. But two other important policy issues relate to data protection and security, given that many students are minors, and vulnerable to possible biases embedded in AI algorithms or in the data that feed them. Massive data collection typically leads to concerns about privacy and data security. While the use of personal data enhances the effectiveness of AI systems in education, the collection and storage of data create new risks for privacy of students. Families are concerned that education institutions or even employers may use “old” data to make decisions, which raises the question of how long and which data could be stored and retrieved to make some decisions. A second question relates to the possible use of the data for commercial purposes in a sphere where commercial interests are often excluded.

2.4.8 Inequality amongst learners

According to (Wogu et al., 2018), AI systems are known to breed natural inequality among learners. Since AI systems naturally customize learning to suit every individual in a group or a class, there is the tendency for such systems to want to tailor the course work for each student according to the capacity of the learner involved. By so doing, AI systems without knowing it, meddles with the standardization that is expected of the course or program. Consequently, while some students progress rapidly, a disturbing proportion of learners, wallow in the state of retrogression, thus breathing inequality among the weak and strong students.

2.4.9 Plagiarism

(Forbes Advisor survey, 2023) revealed that chatbots such as ChatGPT have sparked controversy among educators about their potential to facilitate cheating and generate misinformation.

⁹ Fagbola and Thakur, “Towards the Development of AI-based Systems”.

¹⁰ Michalski, R.S., Carbonell, J.G. & Mitchell, T.M. (2013) Machine Learning: An Artificial Intelligence Approach. Springer Science & Business Media, Berlin.

Most of the teachers we surveyed observed that students were using AI particularly generative AI, which can compose essays and supply answers on demand to cheat. Further (Ibrahim, 2023; Lee, 2023), noted that the introduction of ChatGPT has ushered in a new era of AI-assisted plagiarism, causing disruptions in traditional assessment methods. Educators are grappling with the challenge of controlling AI-assisted plagiarism, especially when conventional detection methods prove ineffective against AI-generated texts.

According to (Marangu, 2023), in the Kenyan education system the emergence of artificial Intelligence tools such as ChatGPT is posing serious challenges. Some academic assistance providers' express concerns that AI tools are impacting their business, as these technologies offer students alternative means of support. Concurrently, professors are apprehensive about the potential for students to exploit these tools, viewing them as new avenues for academic dishonesty and cheating.

2.5 Gender consideration in the deployment of AI in Education in Africa

Gender inequality is a significant challenge in African education systems. Girls often face discrimination and are more likely to be excluded from education compared to boys. Factors such as early marriage, cultural norms, and gender-based violence contribute to the gender gap in education. Addressing gender disparities is crucial for achieving equitable access to education and empowering girls to reach their full potential.

Women remain largely excluded from the AI field. As throughout the technology sector, a significant gender imbalance persists in the AI field. Although the efforts and successes of meetup groups such as Women in Tech ZA, and the Women in Machine Learning and Data Science (WiMLDS, Nairobi chapter) are notable, according to the findings of research by World Wide Web Foundation (2017), women remain largely underrepresented in the field. The study further noted in their research that, a male dominated field has negative implications for the development and impacts of AI. This gender imbalance will reverberate through the job market, and can foster application designs that can reproduce and exacerbate the problems of unequal societies.

According to the latest World Economic Forum's Global Gender Gap Report (2018), only 22 percent of AI professionals globally are female compared to 78 percent who are male. This accounts for the general gender gap of 72 percent yet to close. AI relies on algorithms that learn from real-world data and there is fear that AI applications will inadvertently exacerbate the existing gender biases. Over-representation of men in the design and developments of AI technologies, risks undoing the advances gained over the years in ensuring gender equality in various levels of the society including education.

AI applications can impose different kinds of bias that are inherent in the data that the technology is trained with and uses as inputs, as well as in the way that the processes and algorithms are constructed and used. The development and use of AI in education must not display or practise bias against any gender, age, minority or vulnerable group. A growing body of evidence shows that women and girls, as well as older people, are being left behind in terms of developing AI skills within a lifelong learning perspective.¹⁵ When this is combined with an intersectionality of inequalities, the gender gap in digital skills further contributes to the low share of women among AI professionals and exacerbates existing gender inequalities.

Feast (2019) notes that there have been many incidences of AI adopting gender bias from humans. He cites an example of natural language processing (NLP) that is present in Amazon's Alexa and Apple's Siri. Gender bias occurs during machine learning. An example is in the dataset. If there's not enough women contributing, then there will be holes in the AI's knowledge, and this is why bias errors happen. Machine learning is of course led by humans, which means their own bias will be incorporated within the AI system.

Similarly, research, including UNESCO's 2019 report '**I'd Blush if I Could: closing gender divides in digital skills through education**' unambiguously shows that gender biases are found in AI data sets in general and training data sets in particular. Algorithms and devices have the potential of spreading and reinforcing harmful gender stereotypes. These gender biases risk further stigmatizing and marginalizing women on a global scale.

Despite the critical role women play in societies, unequal access to education, loans, jobs, healthcare, technology, and political discourse are commonplace – and worsened by COVID-19. Technological innovations like artificial intelligence promise to identify and close these gaps through claims of a more data-driven, objective approach, but ironically pose another hurdle for women. Often, these digital systems inadvertently carry the same old analog gender biases AFRICA TECH (2021).

According to UNESCO (2020) report, while AI poses significant threats to gender equality, it is important to recognize that AI also has the potential to make positive changes in our societies by challenging oppressive gender norms. AI, therefore, has the potential of being part of the solution for advancing gender equality in our societies, which is necessary for the realization of SDG4: Access to quality education and life-long learning.

Also, according to UNESCO (2020) concept note, innovative experiences and solutions in different contexts have highlighted the potential of AI and digital technologies for promoting quality education and learning opportunities for students and other learners, including those disadvantaged on the basis of gender, disability, social or economic status, ethnic or cultural background, minority languages or geographic location. These experiences, however, are often experimental examples that have yet to be implemented at scale in most cases.

Elizabeth (2019) also states that Derek Li, Founder of Squirrel AI Learning believes that in the next 100 years, AI can solve inequality in education, thus closing the gender gap and allowing all to better succeed in life. Li believes that individualized education utilizing the power of AI is the only way to achieve that goal. "With AI, opportunity is unlimited."



2.6 Key challenges to deployment of AI in education in Africa

This study also sought to determine the challenges of AI in education in Africa. Several AI challenges in education were found and are discussed below.

2.6.1 Lack of data

A major challenge affecting the effective adoption of artificial intelligence in Africa is the lack of data accessible to African researchers and the relevance of this data to African problems in domains such as agriculture, health care, education and voice/text recognition. According to (Buttice, 2018; Mutisya, 2020) deep learning models must be fed with lots of data to train them, a resource that is currently scarce in Africa. Other than lacking the raw amount of big data that the other highly developed countries collected in the last few years, even the data

that is currently available is often largely irrelevant. The more data is available, the better and more effective results this technology will deliver. However, in regions of the world such as Sub-Saharan Africa, access to large sets of data is limited. Therefore, solutions must be found to ensure AI can bring the most benefit to its population.

Difficulties with availability of data in Africa is well recognized in the context of development, where quality data is indispensable indicators of progress towards the Sustainable Development Goals (SDGs) and an important input for those designing development programs. The UN Economic Commission for Africa (UNECA) describes national data ecosystems in Africa as at “nascent stages of the African data revolution”¹¹. The Open Data Barometer, created by the World Wide Web Foundation, finds that open data initiatives in a majority of Africa’s countries lack long-term commitment and sustainable resources. Other legislative and policy impediments often limit the sharing and use of data not produced by national statistical systems¹².

According to (Gadzala, 2018) lacking or faulty data severely limits the efficacy of AI systems. Discrepancies between on-the-ground realities and data input into AI systems may cause systems to learn incorrectly, yielding erroneous outputs. Skewed input data additionally opens the door for the reproduction and even amplification of human biases and discrimination. The push for more and better data across Africa is constrained by insufficient regulations to protect against data misuse and to ensure personal privacy.

2.6.2 Lack of Infrastructure

Over the past decade, internet penetration within the African continent has risen rapidly from an estimated 10% in 2010 to 28% in 2019 (ITU, 2021). The sore state of internet penetration across the African continent can be blamed on infrastructure issues associated with lack of access to electricity and low investment in internet infrastructure such as fibre-optic cables, cell towers and base stations. Investment in connectivity infrastructure is inextricable from the development of AI. Access to robust, ubiquitous, and affordable broadband infrastructure is a prerequisite for AI development and uptake. While in recent years there has been a dramatic improvement in the quantity and quality of telecommunications infrastructure, Sub-Saharan Africa still has more to do to ensure adequate connectivity infrastructure is in place¹³.

African organizations and entrepreneurs that could be developing AI technology lack access to stable Internet connections and frequently are deficient in even more basic complementary infrastructure like electricity and roads. Without these foundations, AI’s potential benefits will be limited to and enjoyed only by a few elites¹⁴. (Wright, 2020) notes that while AI development in sub-Saharan Africa is hampered by poor infrastructure, lack of skills and regulatory confusion, a handful of countries in the region — spurred by the demand for economic development and recently, by the need to combat COVID-19 — are laying the groundwork for innovation in the technology.

(Buttice, 2018) notes that just like its entire technology infrastructure, the development of AI in Africa is still in a very immature stage. Extremely inconsistent IT infrastructure represents a

11 “The Africa Data Revolution Report 2016”, UNECA.

12 Open Data Baromet/UNECO, page 14l

13 World Bank Group, Africa’s Pulse: An analysis of issues shaping Africa’s economic future, Office of the Chief Economist for the Africa Region, April 2017, Volume 15, p. 35-43

14 World Wide Web Foundation, Artificial Intelligence: Starting the policy dialogue in Africa, December 2017,

major challenge that needs to be addressed by various African governments, mostly because AI requires robust networks, immense computing power, and stable connections. (Gadzala, 2018) in his study concluded that despite enthusiasm about AI being able to help African countries “leapfrog” their economic development, progress in certain areas—in data availability and privacy; in skills and training; in digital infrastructure—first has to happen before AI can be meaningfully mastered and deployed.

(Brandusescu, Freuler, & Thakur, 2017) in their study found out that connectivity, infrastructure and other challenges may limit local AI entrepreneurship. Local entrepreneurs are faced with a number of obstacles to deploying this local expertise in the AI field, including access to stable internet connections, limited sources of finance, and frequently insufficient complementary infrastructure (e.g., electricity, roads). The optimization of AI for education requires an environment with adequate infrastructure, state-of-the-art data facilities and requisite AI expertise, which are largely inadequate in Africa.

In another study (Hashakimana & Habyarimana, 2020) found out that fragile technological infrastructure, inadequate government expenditure in education, achievement gap in education, resistance to implement AIED, and unprepared teacher for AIED implementation were the main challenges of AIED at 85%, 75%, 65%, 60%, and 40% respectively. This study indicated at 85% fragile technological infrastructure, and at 75% inadequate government expenditure in education as the main challenges of AIED which requires enough and sustainable technological infrastructure to serve the purpose.

(Bourhis, 2019) notes that despite rising expectations for the diffusion of AI in Africa, a lack of adequate, readily available technological infrastructure holds back progress. (Youssef, Kevin, 2020) also states that a number of structural challenges undermine rapid adoption and implementation of AI on the African continent. Inadequate basic and digital infrastructure seriously erodes efforts to activate AI-powered solutions as it reduces crucial connectivity. (Nye, 2015) highlights several challenges hindering the implementation and success of AIED system worldwide. Inadequate funding, infrastructure, ICT skills, internet connectivity, language and culture were found most hindrances of AIED.

2.6.3 Lack of Research and development

(Youssef & Kevin, 2020; Akello, 2022) notes that the lack of adequate investments in research and development is an important obstacle. Africa must develop innovative financial instruments and public-private partnerships to fund human capital development, including a focus on industrial research and innovation hubs that bridge the gap between higher education institutions and the private sector to ensure the transition of AI products from lab to market.

(Brandusescu, Freuler, & Thakur 2017) found out that government engagement in the promotion of AI research and use is low. While the governments of all three countries (Kenya, Nigeria and South Africa) have, to varying degrees, taken steps to promote of STEM (science, technology, engineering, and mathematics) education and training, much more can be done. According to interviewees, civil servants are not directly engaging in developing AI solutions for government services, which might hinder their ability to provide appropriate incentives and regulation in the short term. Indeed, outside of financial support for academic research (for example in the case of South Africa), the lack of government engagement in AI, particularly at the policy level, is one of the gaps highlighted by many interviewees in all three countries.

According to (Buttice, 2018) African engineers and AI researchers are very limited in number, mostly because the education system is often insufficient to provide African talent with the necessary degree of specialization. The most brilliant minds have no choice but to complete their academic studies overseas and are, therefore, lost to competition in never ending technology race. There is no network of African institutes of artificial intelligence available to coordinate the efforts made by various African countries, which still need to depend on external aid. This overreliance on help from outside is a serious liability, and, once again, represents a vulnerability that endangers the ability of most African governments to retain their sovereignty.

However, (Besaw & Filitz, 2019) says that governments in AI rich countries like Ghana, Nigeria, Kenya, and South Africa have taken a supportive but cautious approach. Monetary support for AI research and development alongside the promotion of STEM education have taken priority over AI's integration within government agencies.

2.6.4 Lack of Digital Skills Literacy

Digital skills literacy is a significant barrier to the adoption and implementation of artificial intelligence in Africa. Out of all world regions, sub-Saharan Africa has the lowest percentage of citizens equipped with digital skills, totaling to about half of the average level of digital skills adoption seen globally. According to (Chioma, 2020) Africa has the highest youth population in the world, with 60% of the African population under 25 years. How do developments in AI differentially impact this younger generation? To thrive in this world of AI and to be fully empowered in digital spaces, specific skills are required. Digital skills literacy remains a challenge, with few avenues for formal training around not only the use of digital technologies but also more advanced technical skills. With the dawn of the 4th industrial revolution, it is important to prepare the African youth with digital skills at all levels to handle smart machines.

(Youssef & Kevin, 2020; Akello, 2022) also agrees that lack of relevant technical skills, particularly for young people, is a growing threat. This skills gap means that those who would have otherwise been at the forefront of building AI are left out, preventing the continent from harnessing the full potential of transformative technologies and industries. (Gadzala, 2018) notes that in African countries where data ecosystem and infrastructure are wanting, and the workforce is not yet equipped with the skills necessary to adopt and advance AI solutions, the case for the widespread adoption of the technology is often even less clear.

2.6.5 Policy Issues

There is far-reaching policy change which African countries would need to address to successfully incorporate AI in teaching and learning. A comprehensive policy framework, much of which would require overhaul of current policies and creation of new ones, is a prerequisite for fostering participation by industry players and for achieving a sustainable environment where the application of AI of education will thrive. (Besaw & Filitz, 2019) suggest that delivering the promise of positive AI will require good systems of governance, which constitute part of the policy framework.

In expressing the need for appropriate AI policies for education, Ayoub (2020) expresses that educators see AI as instrumental to their institution's competitiveness, yet most institutions still lack a formal data strategy to advance AI. Even though, most African countries have ICT policies that are being implemented effectively, there is still a dearth of AI policies in Africa. Overall, compared to Europe, Canada, the U.S., and China, there is no well-documented

strategy for AI in Africa¹⁵. While we can learn from other regions, we cannot import policies that may not fit the context of African societies. Thus, relevant policies which will create clear directions on the application of AI for education in line with the peculiarities of the African continent need to be developed.

(Youssef & Kevin, 2020) notes that a lack of flexible and dynamic regulatory systems in Africa frustrates the growth of a digital ecosystem that favors AI technology, especially as tech leaders want to scale across borders. (Gwagwa et al., 2020) also states that while AI is clearly developing in countries that are well known as technology hubs (e.g., Kenya, Nigeria, and South Africa), there are also significant AI-focused activities in countries that are less frequently recognized for cutting-edge digital adoption (e.g., Uganda and Ethiopia). In contrast, government policy is an area where there is less diversity, as the vast majority of African countries lack a dedicated AI policy instrument. While it is unclear how many African countries have formally instituted regulation on AI, countries like Senegal, Kenya and South Africa have launched regulatory frameworks, data protection laws and acts regulating automated decision making (Adams, 2021).

2.6.6 Language and locally relevant content

According to (Chioma, 2020), there are different gaps that exist both across and within the different countries in Africa, between urban and rural areas, and according to gender and language. The connectivity challenge in the region leads to AI produced for non-African languages, with less local content and African-produced open-source AI technology, and a dearth of resources for local training. Applications that employ AI are largely built-in major languages such as English and Chinese, and as of now, no application understands many African languages. If these barriers are not eliminated, with more emphasis placed on AI development for local languages and local content, AI will aggravate the digital divide and exclude individuals from the benefits of artificial intelligence.

(Chioma, 2020) further says that in order to build more inclusive AI technologies for diverse groups of Africans, it is necessary to tie initiatives to local communities and their diverse needs. Locals understand the unique needs of each community. In contexts where digital literacy is a barrier, local users should be consulted throughout the development of AI applications. This will create an inclusive environment where, for example, the illiterate farmer in a rural area can better access information on agricultural innovations and pricing using voice-based AI applications, while a local teacher can find new curricula for her students.

15 Nayebara, "Artificial Intelligence Policies in Africa Over the Next Five Years"

3. CHAPTER THREE

CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

The overall objective of this study was to generate evidence that can be used by stakeholders and policy makers to accelerate the deployment of artificial intelligence in the education sector while providing measures to address any fears and ethical issues as well as challenges that may affect the deployment of AI to a scale that can have impact in the education sector in Africa. From an exhaustive search through using Systematic Literature Review (SLR) method, we selected several studies that would provide answers to the five established research objectives. The conclusions obtained in this paper in relation to the proposed objectives are set out below.

3.1.1 Possible areas of deployment of AI in education in Africa

Our results show that there are several possible areas of deployment of AI in education in Africa. Some of the areas identified included personalized learning, improving students' progress, intelligent tutoring systems, supporting teachers, improving course contents, intelligent tutee, policy-making advisory, simplifying administrative tasks, improving quality of education, collaborative learning, accessible and inclusive education, reducing the cost of education, reducing poverty and boosting shared prosperity and reducing school dropout rate. Most of the studies reviewed identified personalized learning as one of the most important roles of AI in education. The study concluded that Africa can actually use AI in education to improve education outcomes; and that AI in education has the potential to be as impactful in Africa as it is in other regions of the world.

3.1.2 Perceived and real fears and negative impacts of AI in Education in Africa.

This study further found out some of the perceived and real fears and negative impacts of AI in education in Africa. These perceived fears and negative impacts identified included Job losses, Isolation and individualization and technology addiction. Also, AI systems can breed natural inequality among learners, breach privacy, bring about security concerns, create inequality amongst learners and worsen plagiarism. We concluded that if these perceived and real fears and negative impacts of AI in education in Africa are not addressed, then it will hinder or slow down its deployment in the continent.

3.1.3 Success stories of AI deployment in Education in Africa and elsewhere.

This study documented some success stories of AI deployment in education in Africa and elsewhere. This study found out that there are many success stories of AI deployment in Education in Africa and elsewhere. The study therefore picked a few of these success stories including M-Shule, Daptio, Eneza Education, SmartClass and Gradely. However, the study

found out that these success stories have been implemented on a small scale in Africa. Utilization of AI technologies in education in Africa can provide solutions to some of the continent's most difficult educational problems from inequality and poor education to lack of teachers and students drop out rates. Although deployment of AI in Africa's education system will bring its share of problems, the benefits will far outweigh the costs.

3.1.4 Gender consideration in the deployment of AI in Africa's education system

This study investigated gender considerations in the deployment of AI in Africa's education system. The study found out that while AI poses significant threats to gender equality, it is important to recognize that AI also has the potential to make positive changes in our societies by challenging oppressive gender norms. Further, the development and use of AI in education must not display or practice bias against any gender, age, minority or vulnerable group. AI can solve inequality in education, thus closing the gender gap and leaving no one behind.

3.1.5 Key challenges to deployment of AI in Education in Africa

This study found out several key challenges to deployment of AI in education in Africa. The challenges include lack of data, poor infrastructure, little or lack of research and development, inadequate skills and training, policy gaps and a dearth of locally relevant content. If these challenges are not addressed by African countries, it will hinder or slow down the deployment of AI in Africa's education in Africa.

3.1.6 Impact of COVID-19 on the digitalization of education in Kenya

This study documented some impacts of COVID-19 on the digitalization of education in Kenya. The study found out that digitalization of education in Kenya was affected both positively and negatively by the COVID-19 crisis. The impact includes accelerated digital transformation in education, digital literacy and embracing of technology, psychological agony, lack of digital preparedness and educational inequalities due to the digital divide. In the post-COVID-19 era, virtual learning systems have become integral to education, offering flexibility and accessibility. Despite the challenges, COVID-19 provides an opportune moment to rethink education systems and to 'build back better' with greater innovation. Digitalization of education in Kenya will reshape the future of education by combining technological advancements with evolving pedagogical approaches.



3.2 Recommendations

On the basis of the findings and consequent conclusions, the following recommendations are proposed:

- 1. Development of training data:** African governments should develop mechanisms for collecting AI training data for localized use in the continent.
- 2. Provide proper infrastructure:** African countries must invest in connectivity infrastructure in order to ensure affordable broadband and adequate power to enable consumers to access AI-enabled educational applications and services.
- 3. Privacy and security concerns:** African countries should put in place proper data protection legislation, regulation and standards across governments, companies and civil society.

4. **Investment in research and development:** African governments should enhance research on AI in education by investing in long-term public investment, and encouragement of private investment in research and development (R&D).
5. **Skills development:** African governments should involve and prepare youth with AI skills by investing in education programmes to build the technical competences of future generations.
6. **Policy development:** African countries should come up with appropriate policies and legislation that provide guidance to institutions on how data and AI-driven technologies in education should be used without harm.
7. **Gender issues:** African countries must ensure that inclusion, equity and gender equality are adopted as core values in order to ensure that the development and use of AI in education does not deepen digital divides, gender gaps or inequalities in access to and creation of knowledge and skills.

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ANNEX 1

Table 4: Quality Assessment of Included Studies

STUDY ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	TOTAL CORE	% MAX S
IM-1	1	1	0.5	1	1	1	0.5	1	1	8	89
IM-2	1	1	0	1	1	0.5	0.5	0.5	1	6.5	72
IM-3	1	1	1	1	0.5	1	0.5	1	1	8	89
IM-4	1	1	0.5	1	0.5	0.5	1	1	1	7.5	83
IM-5	0	0	0.5	0	1	0.5	0.5	1	1	4.5	50
IM-6	0	0	1	0	1	0	1	1	1	5	56
IM-7	0	0	0.5	0.5	1	0.5	0.5	1	1	5	56
IM-8	0.5	0.5	0.5	0.5	1	0	0.5	1	1	5.5	61
IM-9	1	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	4.5	50
IM-10	1	1	0.5	1	0.5	0.5	0.5	1	1	7	78
IM-11	1	0.5	0.5	0.5	1	0	0	1	1	5.5	61
IM-12	0.5	0.5	1	0	1	0.5	0.5	0.5	0.5	5	56
IM-13	1	1	0.5	1	1	0	1	0	0.5	6	67
IM-14	0.5	0.5	1	0.5	0.5	0	0.5	0.5	0.5	4.5	50
IM-15	0	0	0.5	0	1	1	0.5	1	1	5	56
IM-16	1	1	1	0	1	1	1	1	1	8	89
IM-17	0	0.5	0.5	0	1	0	0.5	1	1	4.5	50
IM-18	1	1	0	0.5	0.5	0	0.5	0.5	0.5	4.5	50
IM-19	0.5	0.5	1	1	0.5	1	1	1	1	7.5	83
IM-20	1	1	0.5	1	0.5	1	0.5	1	1	7.5	83
IM-21	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.5	50
IM-22	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	4.5	50
IM-23	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	5	56
IM-24	1	1	0.5	0.5	0.5	1	0.5	1	1	7	78
IM-25	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	1	5.5	61
IM-26	1	1	0.5	0.5	0.5	0.5	1	1	0.5	6.5	72
IM-27	1	0.5	0.5	0.5	0.5	0.5	0.5	1	1	6	67
IM-28	1	1	0.5	1	1	0.5	0.5	0.5	0.5	6.5	72
IM-29	0	0	0.5	0	1	0.5	0.5	1	1	4.5	50
IM-30	1	1	1	0.5	0.5	0.5	1	1	1	7.5	83
IM-31	0	0	1	0.5	0.5	0.5	0.5	0.5	1	4.5	50
IM-32	1	0.5	0.5	1	1	1	0.5	1	1	7.5	83
IM-33	0	0	0.5	0.5	1	1	0	1	1	5	56
IM-34	1	1	0.5	1	0.5	0	0	0.5	0.5	5	56
IM-35	0	0	1	0.5	0.5	0.5	0.5	0.5	1	4.5	50
IM-36	1	1	0.5	1	1	1	1	0.5	1	8	89
IM-37	1	1	1	1	1	1	0.5	0.5	1	8	89

ANNEX 2

Table 5: Summary of Role and Impact of AI in Education

Study ID	Author	Role and Impact of AI in Education
IM-1	Onalapo & Onifade (2020)	<ul style="list-style-type: none"> ➤ AI allows smart learning ➤ AI can reinforce student learning ➤ AI will potentially eradicate learning inequality in Africa ➤ AI will give flexibility to teachers in African educational institutions ➤ AI systems will support the teacher and reduce workload by automating tasks ➤ AI will help educators have greater insight students' progressing ➤ Act as a personalized learning resource allocator for students ➤ Policy issues ➤ Infrastructure ➤ Security and related data Issues
IM-2	Chen et al. (2020)	<ul style="list-style-type: none"> ➤ AI has enabled or improved teacher effectiveness and efficiency ➤ AI has resulted improved instructional quality ➤ AI has provided students with improved learning experiences through customization and personalization of learning.
IM-3	Ahmad et al. (2020)	<ul style="list-style-type: none"> ➤ support teachers ➤ predict student performance ➤ evaluate and grade students ➤ improve course contents ➤ Student retention and dropout ➤ Intelligent Tutoring Systems ➤ job creation ➤ Reduce poverty ➤ AI may put students (kids) at risk ➤ Increases the cost of power ➤ It causes joblessness ➤ Isolation and Individualization ➤ Lack of training data ➤ High risk due to biased data ➤ Security concerns ➤ Privacy Issues
IM-4	Hashakimana & Habyarimana (2020)	<ul style="list-style-type: none"> ➤ job losses ➤ ethical aspects ➤ fragile technological infrastructures ➤ inadequate government expenditure in education - resistance to implement AIED ➤ unprepared teacher for AIED
IM-5	Ndemo (2019)	<ul style="list-style-type: none"> ➤ enabling accessible and inclusive education ➤ enables differentiation ➤ AI will not replace teachers

IM-6	Getsmarter (2019)	<ul style="list-style-type: none"> ➤ Teachers' jobs are not at risk of being replaced by robots ➤ job opportunities for data and analytics skills will increase ➤ providing teachers and schools with innovative ways to understand how their students are progressing
IM-7	Ayoub (2020)	<ul style="list-style-type: none"> ➤ AI's potential to change the way teachers teach and students learn, ➤ AI can also help educators foster greater inclusivity ➤ use AI to offer a truly personalized learning experience ➤ there is still a dearth of AI policies in Africa
IM-8	Nzoka, (2024)	<ul style="list-style-type: none"> ➤ access to quality education
IM-9	Sagenmuller, 2017)	<ul style="list-style-type: none"> ➤ dealing with administrative tasks ➤ Personalized learning
IM-10	(UNESCO, 2019)	<ul style="list-style-type: none"> ➤ Collaborative learning ➤ AI could be used to improve learning and equity in education ➤ Job losses
IM-11	(UNESCO, 2020)	<ul style="list-style-type: none"> ➤ promote inclusive and equitable education
IM-12	B. Makala, M, Schmitt, A. Caballero (2021)	<ul style="list-style-type: none"> ➤ expanding the availability of education ➤ closing achievement gaps by coaching learners ➤ personalizing learning ➤ Lack of Digital Literacy ➤ Lack of Expertise
IM-13	G.-J. Hwang et al. (2020)	<ul style="list-style-type: none"> ➤ Intelligent tutor ➤ Intelligent tutee ➤ Intelligent learning tool or partner ➤ Policy-making advisor
IM-14	Michael Rasugu (2019)	<ul style="list-style-type: none"> ➤ increase the efficiency of education ➤ help educators empower students with different backgrounds and abilities ➤ provide educators with greater insight as to how students are progressing ➤ outdated technology
IM-15	Elhoussein et al., (2024)	<ul style="list-style-type: none"> ➤ Providing Personalized Learning Platforms ➤ monitor student progress ➤ Support teachers
IM-16	van der Vorst et al. (2019)	<ul style="list-style-type: none"> ➤ Reducing the workload of teachers ➤ Personalized learning ➤ Supporting the teacher with data-driven insights (learning analytics) ➤ Improved Assessment

IM-17	Gibson, 2023	<ul style="list-style-type: none"> ➤ Personalize Education ➤ Produce Smart Content ➤ Contribute to Task Automation ➤ Do Tutoring ➤ Ensure Access to Education for Students with Special Needs
IM-18	(DAIA, 2020)	<ul style="list-style-type: none"> ➤ AI can assist in raising the levels of education for the poor children
IM-19	(Popenici & Kerr, 2017).	<ul style="list-style-type: none"> ➤ AI could not replace the teachers, however it may lead to the transformation of the profession
IM-20	Klutka et al. (2018)	<ul style="list-style-type: none"> ➤ AI supports teachers and instructors, but does not replace them.
IM-21	Macha (2017)	<ul style="list-style-type: none"> ➤ Reduce the dropout rate in schools
IM-22	Ocaña-Fernandez, Valenzuela-Fernandez, & Garro-Aburto (2019)	<ul style="list-style-type: none"> ➤ Globalized Social Learning (Use of MOOCs) ➤ digital skills
IM-23	Frost & Sullivan (2017)	<ul style="list-style-type: none"> ➤ Use of MOOCs
IM-24	(Bowman, 2023)	<ul style="list-style-type: none"> ➤ eradicate learning inequality ➤ personalized learning
IM-25	(Hooijdonk, 2019)	<ul style="list-style-type: none"> ➤ Improve quality of education
IM-26	Brandusescu, Juan Ortiz Freuler, and Dhanaraj Thakur (2017)	<ul style="list-style-type: none"> ➤ Local knowledge trends. ➤ Connectivity ➤ infrastructure ➤ Promotion of AI research and use are low. ➤ Public data is in short supply. ➤ Develop and retain local AI talent.
IM-27	(Akgun & Greenhow, 2022)	<ul style="list-style-type: none"> ➤ data availability and privacy ➤ skills and training ➤ digital infrastructure
IM-28	Zawacki-Richter et al. (2019)	<ul style="list-style-type: none"> ➤ Lack of Digital Literacy ➤ Lack of Expertise ➤ Privacy
IM-29	Claudie Buttice (2018)	<ul style="list-style-type: none"> ➤ IT Infrastructure ➤ Lack of raw data ➤ Limited number of African Engineers and Researchers
IM-30	(Nye, 2015)	<ul style="list-style-type: none"> ➤ infrastructure, ➤ ICT skills, ➤ internet connectivity, ➤ language ➤ culture
IM-31	(Besaw and Filitz, 2019)	<ul style="list-style-type: none"> ➤ support for AI research and development

IM-32	Youssef, Kevin (2020)	<ul style="list-style-type: none"> ➤ Inadequate digital infrastructure ➤ lack of flexible and dynamic regulatory systems ➤ lack of relevant technical skills ➤ lack of adequate investments in research and development
IM-33	(Wright B., 2020)	<ul style="list-style-type: none"> ➤ poor infrastructure ➤ lack of skills ➤ regulatory confusion
IM-34	Gwagwa et al., 2020)	<ul style="list-style-type: none"> ➤ lack a dedicated AI policy instrument
IM-35	(Chioma Nwaodike, 2020)	<ul style="list-style-type: none"> ➤ Lack of skills ➤ Language and Locally Relevant Content
IM-36	(Haseski, 2019)	<ul style="list-style-type: none"> ➤ effect of artificial intelligence on education is the possible destruction of the teaching profession
IM-37	(Vincent-Lancrin & Vlies, 2020)	<ul style="list-style-type: none"> ➤ skills challenge ➤ security issues

