Towards the Integration of Artificial Intelligence in Higher Education, Challenges and Opportunities: The African Context, a Case of Zimbabwe.

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DOI: https://dx.doi.org/10.47772/IJRISS.2024.803028S

Received: 20 March 2024; Revised: 05 April 2024; Accepted: 09 April 2024; Published: 14 May 2024

ABSTRACT

This paper seeks to address the challenges of underdevelopment bedeviling the African continent in general and Zimbabwe in particular on the integration of Artificial Intelligence (AI) in higher education. Universities in Africa have over the years produced many graduates in Science, Technology, Engineering, and Mathematics (STEM) related learning areas but continue to grapple with underdevelopment both economically and intellectually. Part of the problem has been identified as a lack of quality in the education system that is not able to produce graduates with adequate 21st-century skills for the achievement of the Sustainable Development Goals (SDGs) to fulfil the Global Agenda 2030. Achieving this is possible if Africa moves a step forward and embraces modern technologies like the integration of AI in her education system. A technologically astute graduate would be able to apply their knowledge in achieving the much-needed sustainable economic development. This article highlights how the implementation of AI in higher education can foster a turnaround in Africa's education systems and lead to industrialisation and innovation. Pivotal aspects of AI like the Turing machine test, cloud computing, big data, and machine learning are explored in an attempt to add value to the current education discourse. This study is situated in the interpretive paradigm, the qualitative approach was employed to gather data using several methods like e-questionnaires (open-ended), document analysis, and review of journals and other academic publications. Purposive sampling of STEM educators from a renowned university in Zimbabwe was undertaken to gather information on the ground and the data was thematically analysed. The article argues that Africa has the potential to be a leader in Industrialization and commerce should the continent fully embrace AI in higher education.

Keywords– Intelligence, Artificial intelligence in education, Chatbot, Machine learning, Zimbabwean higher education

INTRODUCTION

In this article, we aim to delve into the intricacies of artificial intelligence (AI) and give a comprehensive overview of its potential benefits to the education sector, with a particular focus on Zimbabwe. The primary aim of this discussion is to encourage the integration of AI technologies in Africa, and specifically in Zimbabwe. The content is based on a detailed and extensive review of literature from various sources, including articles, journals, documents, and data from a university in Zimbabwe. The article highlights the challenges and opportunities associated with the adoption of AI in the education sector and aims to generate interest in the subject matter. While the overview is not exhaustive, it is intended to inspire further research into related topics and promote the advancement of AI systems in Zimbabwe and across Africa. Another objective is to assist the education fraternity in formulating policies and strategies for the effective

implementation of AI in higher education.

In this discussion, intelligence is viewed as a trait that is characterized by cognitive abilities such as learning, adaptability, and decision-making capabilities. These abilities enable individuals to respond to situations rationally, think abstractly, and solve complex problems. Artificial intelligence is a rapidly evolving field of study that applies computer technologies to develop machines capable of exhibiting human-like cognitive abilities, including learning, interacting with the environment, and problem-solving. The integration of AI in education has been gaining traction over the years, with the advent of computer-aided learning, online resources, and interactive computer packages that leverage AI to enhance the learning experience. In this context, our article seeks to provide a comprehensive overview of the challenges and opportunities presented by AI in education (Pietikäinen and Silvén, 2021).

Machine learning can be defined as a branch of AI that employs algorithms to identify patterns in data, continually enhancing the abilities of computerized machines to make informed decisions on novel situations based on fresh data not necessarily pre-programmed (Ramlakhan et al., 2022). This seems to imply that machines can learn to read and understand human language and process an appropriate response upon request. This can be taken advantage of to use these machines to develop a personalised or learner-specific education system to cater to learners with different academic abilities to achieve the same specified goals of attainment, albeit at different rates. Machines can learn through conversing with several humans how to respond to particular given questions by developing a database of frequently asked questions on any subject matter. They can generate patterns, and personalised structured learning systems and help learners advance in their studies. These machines can analyse the learner's knowledge level, learning ability, likes, dislikes, and academic behaviour and advise on future progress including the selection of further courses of study and academic institutions to attend (Ku£ak, Juri£i¢, and Dambi¢,2018).

All this can significantly assist the modern educator to more accurately gauge each learner's achievement rate by analysing the machine-generated results and thus be in a better position to assist the learner to improve in specific areas. This will ultimately improve the quality of education offered by educators and institutions of learning.

Education chatting robots (chatbots) are online robots that facilitate conversation between humans and computerised machines on educational issues in various learning areas using natural human language (Bradesko, Mladenic, 2012). This asserts that modern machines can understand human language and thus can be used to advance the quality of education due to their ability to store large amounts of information and reproduce it in several forms upon request by a human (Anghelescu and Nicolaescu, 2018). This makes chatbots versatile tools for improving the quality of higher education as they converse with students and answer questions given to them instantly. Zimbabwe cannot afford to be left behind in this education revolution. Students can benefit from quality tuition offered by teachers in any geographic location online. Chatbots can learn (through machine learning) to simulate human behaviour and natural conversation and answer questions such that one cannot tell whether they are chatting with a human being or a machine provided the machine has passed the Turing test. AI systems have the advantage of providing 24-hour virtually available teachers or teaching colleagues as compared to natural humans who can be only available for certain periods.

METHODOLOGY

Interpretivist paradigm

This study is situated in the interpretive paradigm, the qualitative research approach was employed to gather data using research instruments like open-ended e-questionnaires, semi-structured interviews, and document analysis and review of journals and other academic publications. A case study design was employed to

obtain a rich, in-depth understanding of the phenomenon studied. Purposive sampling of STEM educators from a renowned university in Zimbabwe was undertaken to gather first-hand information on the ground. The collected data was thematically analysed.

Research approach

A qualitative research approach was chosen because it allows the analysis of words and their contextual meaning, people's behaviours and expressed emotions. These provide a real-life scenario of what is obtained on the ground at a particular place and time. In this study, researchers wanted to acquire a deep understanding of the challenges and opportunities in AI integration. This type of study calls for a deep understanding of stakeholders' views and emotions which can be studied more effectively qualitatively. This sentiment resonates with that of Silverman (2000:8) who asserted that Qualitative methods are more interested in understanding facts than in numerical analysis of data. In this paper, the qualitative research approach was preferred also because it is a versatile research approach that facilitates an in-depth comprehension of complex phenomena like AI integration and provides for deep analysis based on personal experiences and points of view of the affected individuals (Mantula, Mpofu, Mpofu, Shava, 2024).

The qualitative research approach is embedded in the interpretivism paradigm, which seeks to explore and analyse social problems to understand the reasons behind people's experiences according to the particular situation they are facing and may not necessarily be generalizable to the entire population or other related populations. The arguments posed by this paper are not a one-size-fits-all, no claim is made that they will apply to all crises in Zimbabwe and abroad although measures have been taken to ensure this, including extensively studying literature from other countries, carrying out debriefing exercises and member checking to come up with reliable information. Interpretivism allows the researchers to ascribe meanings to situations, behaviours and their findings contextually, albeit according to known theories and beliefs (Addo & Eboh, 2014).

Qualitative research helps to contextualize and situate phenomena within their social, cultural, and historical contexts. It explores the intricate relationships, dynamics, and influences that shape individuals and communities, providing insights into how social factors impact behaviours, beliefs, and interactions. Qualitative research allows for in-depth exploration and understanding of phenomena that are difficult to capture using quantitative methods alone. It provides rich, detailed, and context-specific data that go beyond surface-level descriptions, enabling researchers to gain a deeper understanding of the participants' perspectives, meanings, and lived experiences (Addo and Eboh, 2014).

Case study design

The incumbent research adopted a case study design to obtain a closer to real-life situations and their multiple wealth of details. This is important in two respects. First, it is important for the development of a nuanced view of reality, including the view that human behaviour cannot be meaningfully understood as simply the rule-governed acts found at the lowest levels of the learning process and in much theory. Secondly, Case studies involve in-depth investigations of specific individuals, groups, organizations, or phenomena in their natural settings to understand the real issues on the ground. The researchers collected and analysed multiple sources of data obtained from semi-structured interviews, open-ended questionnaires, and document analysis to gain a comprehensive understanding of the factors affecting AI integration in education in Zimbabwe (Bent, 2006).

Sampling techniques

Purposive sampling was applied because it offered a deliberate choice of informants most likely to provide accurate data due to their desired qualities and knowledge base of the phenomenon being studied, STEM

practitioners and educators formed the sample to collect primary data as they were perceived to possess the required information about AI systems. However, this sampling technique may be prone to researcher bias in selection as the researchers would select particular individuals known to them personally at the expense of those who might have more valuable information but not within their circle of influence. This perceived bias was circumvented by holding professional discourse among the four researchers and consultation with other academics and researchers not part of this study (Yin, 2011).

Data collection instruments

The researchers used both physical and virtual semi-structured interviews (as appropriate in each case) to collect data from lecturers. Predetermined questions were administered but room was given for additional open-ended relevant and follow-up questions (determined as per case) to obtain richer in-depth information from the discussion. Some important information was obtained by studying people's attitudes and body language during discussions. This is supported by Creswell (2011) who also asserted that Interviews are useful for getting the story behind a participant's experience which can be vital in interpreting their responses.

Document analysis was carried out to obtain useful secondary data from journals, textbooks, periodicals, and the Internet and conference proceedings. Careful analysis involving discussion seminars among the researchers and other professional colleagues mostly within the institution ensured giving an analytic and comprehensive interpretation of the phenomenon studied hence allowing for drawing a comprehensive conclusion and offering objective and practical recommendations and possible solutions that can help Zimbabwe and other African countries integrate AI in their education systems. Document analysis also gave the researchers an insight into the situation in other countries around the globe about AI adoption.

Validity, trustworthiness, reliability

According to Noble and Heale (2019), research triangulation refers to the process that helps to increase the credibility and validity of research. Triangulation involves using multiple sources of data, methods of data collection, or researchers to examine the same phenomenon. By employing different data collection techniques, the incumbent researchers could compare and cross-validate findings, reducing the risk of bias and increasing the reliability of the study (Halcomb and Andrews,2005; Casey and Murphy,2009). According to Redfern and Norman (1994) some benefits of triangulation include increased confidence in the findings and a more comprehensive understanding of the research topic. It helps address potential biases, limitations, or weaknesses associated with a single method or data source. However, triangulation also requires careful planning and consideration of the research design, as it can be time-consuming and resource-intensive.

The specific strategies used to attain trustworthiness were peer debriefing, prolonged engagement persistent observation, and member checks. Consent was sought from participants in interviews and respondents in questionnaires, all participants and respondents were assured of the privacy and confidentiality of their responses thus no identification marks or names were required from their responses to questionnaires and during discussions. This was an effort to observe ethical principles. After transcribing views of people in data collection, member checking was carried out to validate collected data, carrying out corrections where appropriate, and verifying with informants that information was more or less accurately captured. Professional colleagues and fellow researchers interested in similar fields of study were engaged in formulating interpretations of data obtained from both primary and secondary sources. This constituted the peer debriefing procedure which also aided in improving flexibility (Guba & Lincoln, 1982).

Prolonged engagement with participants and literature study gave way to a deeper understanding from a theoretical as well on the ground practically prevailing situation. This facilitated the formulation of a thick

and rich description of the phenomenon.

Adoption of AI in teaching and learning and its benefits

The adoption of AI in institutions of higher learning in Africa including those in Zimbabwe is generally in its infancy even though it has profound benefits. AI offers the opportunities to achieve the SDGs and to transform Zimbabwe into a middle-class economy as envisaged by her government authorities. AI involves using a lot of data to develop personalised learning systems for different classes of learners. According to Strongbytes (2017), this can result in improved academic results by generating learning experiences that are best suited to a particular student. This ultimately results in the production of graduates who are better prepared to face the challenges of the 21st century. AI systems are dependent on machine learning. This involves the ability of a machine to utilise some software and algorithms to perform tasks that normally require human intelligence and cognition to be able to adapt to changing environments in a bid to solve problems peculiar to that given environment or system (Pokrivcakova,2019; Wartman & Combs, 2018).

A noted key area of concern in many education systems in Africa is the unavailability of large amounts of data about individual students. For AI to be successfully implemented, computer systems must have access to data about different students, their learning abilities, personal attributes, and cultures. This will enable the creation of a personalized education system to cater to different students and will greatly assist learners with special educational needs (SEN) because these students have individualised needs that most students in a given class do not have. Profound financial Investment and infrastructural development in machine learning, data mining, and the creation of huge databases of information is therefore imperative. Modern computerised machines can intelligently extract relevant data and create a study pathway for different students even if they were not particularly programmed to do so. The storage of large amounts of data in the cloud and its availability on the internet provides a means to utilise AI. Africa needs to tap into this to enhance its transition towards achieving quality education. (Tuomi, 2018; Timms, 2016).

AI includes several types of embedded systems that utilise intelligent web-based technologies that can be applied to work together with educators in performing mostly routine tasks like marking registers, creating and grading assignments and tests, and responding to general questions about a particular learning area for example Physics, Chemistry, or Mathematics. Such artificial colleagues are called colleague robots (cobots). These cobots lessen the burden and workload of teachers by taking care of routine and predictable tasks so that human teachers can concentrate more on abstract and cognitively challenging aspects of their jobs like researching and designing better teaching and learning methods to improve the education delivery system. Compared to humans, machines are often more efficient in carrying out given routine tasks thus working with them greatly improves the educator's output, efficiency, and effectiveness. Chatting robots (chatbots) have been developed that can respond to student's questions more or less similar to automated responses in many communication systems and popular search engines like Google and Bing. If large amounts of data are available, the machines can learn to quickly go through these and select the correct information to give to the enquiring student. This can be beneficial and time-saving to both learners and educators. Higher education in Africa can greatly improve with the adoption of such learning systems and achieve SDG number 4 on the provision of quality education (Chassignol, Khoroshavin, and Bilyatdinova, 2018).

AI has the power to create virtual reality and three-dimensional (3D) images. This is a powerful teaching tool that can show learners 'real' images of objects they may never see in real life. Some machines, apparatus, or objects are very important in particular learning areas that are not readily available in the local scenario or geographic location of the teacher and or learner. Zimbabwe has many remote schools with no or poorly resourced physical laboratories. Learners can get the opportunity to interact with state-of-the-art resources through simulations provided by AI technologies to promote quality STEM education. Hence AI integration is the alternative to give students the much-needed practical experience. During the COVID-19 pandemic carrying out some experiments in science laboratories was not feasible given the restrictions

imposed, thus online simulations become very important in fostering practical knowledge to learners in times of crisis. This is one area where AI is needed so that a student in Africa is not left behind in terms of global technological advancement. The adoption of AI may make a student in a higher education institution in Africa study whatever learning discipline and be competitive in the global market. (Mikropoulos and Natsis, 2011).

AI SYSTEMS

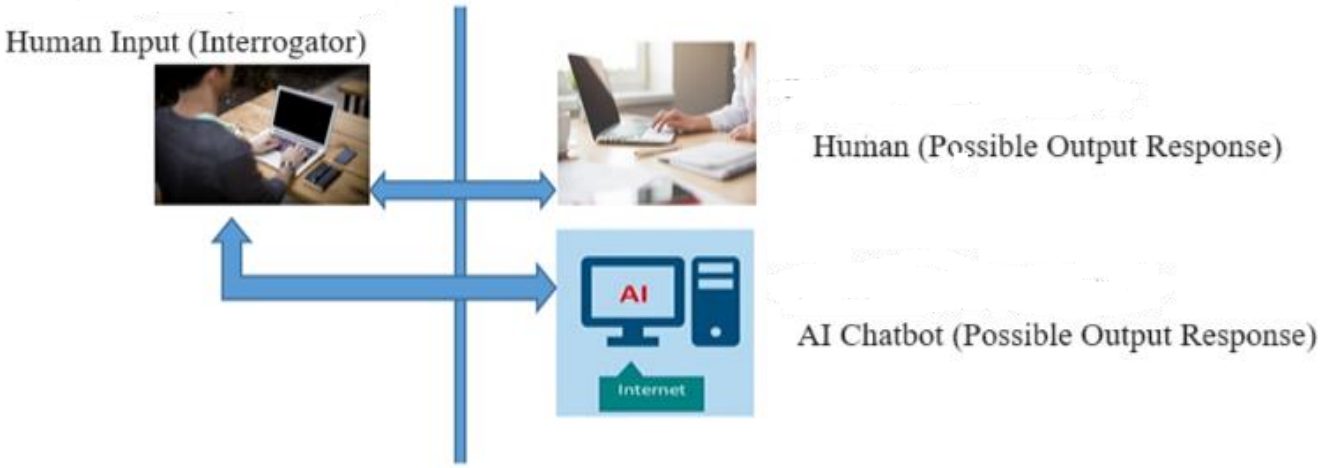

Fig 1.1 Movement of data in an AI system (Picture generated by J. Hlongwane 2024)

Fig 1.1 illustrates the basis of the Turing test developed by Turing in 1950. A human being at the input end asks questions to two different systems, one manned by a human being and the other one by a computer-based AI system. If the responses from both systems are comparable such that the human interrogator cannot easily distinguish between the two systems, then the machine passes the test to represent a human being, it is taken to have human-like intelligence capable of generating conversations in real-time using natural human language(s) (Russell & Norvig, 2010). Such a machine can be relied upon to act as a Chabot or cobot in the education system to respond to student's questions in any given subject matter at any time. Examples of such intelligent machines include International Business Machines (IBM) Watson, Apple's Siri, Amazon's Alexia, Microsoft's Cortana, and Google's Assistant (Reis et al., 2018). Students in several universities around the globe communicate with these chatbots and get satisfactory responses similar to or even better than those from their human teachers. This demonstrates the immense power of AI systems. This article argues that Zimbabwe and the rest of Africa can benefit from the development or adoption of such AI systems in her local institutions of higher learning to provide a round-the-clock quality learning experience for students including those in remote rural areas where there is a shortage of learning resources, both human and material.

Some AI systems are knowledge-based Intelligent Tutoring Systems (ITS). It integrates information on a particular learning area (say Physics) and information about the student like their current knowledge base and interests. The system then designs a learning model suitable for the learner via an interactive interface. The student can enjoy an interesting, personally stimulating, and friendly learning experience. The system monitors the performance of the learner and provides corrective mechanisms and suggestions for improvement in real time including giving further information and remedial work where appropriate. Such systems offer opportunities to upgrade slow learners to the level of their more academically gifted peers without embarrassing them by for example having a teacher repeat the same information to them several times in front of others who have already grasped the concept. ITS systems can use information about students' grades, class attendance patterns, and reasons for absenteeism, health records to predict whether some students are likely to succeed or fail a particular course or module. Those at risk of failure can be

remediated at an early stage. Student dropout rates can also be reduced by identifying those most likely to drop out and intervening before they drop out. This is an opportunity to improve the graduation rates and also improve the delivery of quality education. (Woolf, 2009).

Artificial intelligence offers sustainable solutions to the continuance of education during pandemics like the recent Covid-19 scourge. The teacher-student interaction can be mechanised and improved by applying AI technologies and machine learning. This can offer a more efficient and effective learning platform that is more or less better than physical human teacher presence and application of traditional online learning where teacher and student exchange information using computers and non-interactive technologies. Chatbots used in AI offer the student a round-the-clock 'personal' interaction and vocal presence of the instructor even if they are not physically present. With more developed AI systems, the learner might not even know that they are chatting with a robot. Baskara (2023) posited that Chatbots are instrumental in flipped classrooms by availing learner-specific assistance and guidance, encouraging group discourse, providing instant feedback and grading on any given task, allowing students to learn at their own pace, and providing individualised motivational factors. This emphasises the ability of AI systems to be used alongside other teaching methods to enrich the learning process. Beneficial collaborations among learners, among teachers, and between learners and teachers can be easily created with no respect for geographic boundaries. AI has the potential to bridge the gap between the education systems in Africa and the more advanced Western and Eastern systems. Most AI systems are internet-based thus no physical boundaries can hinder the delivery of quality STEM education to learners in Africa by virtual teachers without having to travel abroad. They can also collaborate and share information with other students in several different countries.

Possible challenges to be faced in integrating AI into higher education in Africa

Access to a massive amount of data is required for machine learning. For an AI system to develop an accurate personalised teaching and learning environment it must have access to a lot of individual personal and private information. Many African countries, Zimbabwe included don't have readily available databases with such enormous data. Another big challenge is the possibility of leaking such personal information to the public domain. This may pose a security threat to individuals and nations. Therefore strong cyber security systems also have to be developed alongside AI systems to preserve the privacy and confidentiality of some information about individuals. Some unscrupulous criminal elements can use this huge amount of data to perpetrate several cybercrimes whose description is beyond the scope of this article (Carmody, Shringarpure, and Van de Venter, 2021).

Some educators in Higher Education Institutions (HEI) in Zimbabwe are sceptical about the integration of AI in teaching and learning, they fear that their jobs will be taken over by machines in the future. This article posits that certain aspects of their jobs, especially routine tasks can be done more efficiently and effectively by computerised machines with programmed AI systems. But alas, no amount of machine learning can result in machines thinking exactly like humans, they can only simulate thinking and rational behaviour. It is of note that humans can create machines but machines cannot create humans. Machines do not have the advanced natural cognitive ability to make complex decisions like humans despite using complex algorithms and neural networks. (Haugeland, 1985). Machines can only assist humans and not replace them. Machines can carry out certain tasks (mostly routine and predictable) very effectively but they can hardly explain how and why they do what they do.

Some people fear that AI will replace them in workplaces and increase unemployment. This is not necessarily so, as machines take over some jobs humans must advance to other jobs more cognitively challenging than what happened during the agricultural and industrial revolutions when much labour moved to services. The education system should provide people with skills to utilise AI and not be replaced by it. The modern education system should prepare people for the Fourth Industrial Revolution (4IR) era

(Acemoglu and Restrepo, 2016; Autor, 2015).

Some challenges with the integration of AI in African education systems are beyond the control of educationists, they are political. Many Higher education institutions (HEI) in Africa are either sponsored by or controlled by the government of the day, thus all educational policies are made by politicians in government offices who may not be aware of the global technological trends in education. This article envisages that their decisions may be clouded by the political agendas of their political parties and not by a desire to improve and advance the education sector. (Woodhall, 2003).

Many students in developing countries like Zimbabwe do not have access to modern technology devices like laptops, smartphones, and tablets required to access AI systems (Azubike et al., 2021). Many students from rural areas and some economically challenged ones from urban centres can hardly afford to purchase these gadgets despite having a strong desire to apply AI technologies in their education. It is worrisome to note that even some teachers and lecturers cannot afford these machines from their meagre salaries. This is a major aspect that can hinder the adoption and integration of AI in higher education in Zimbabwe and many countries in Africa. However, there are some students and faculty who can afford state-of-the-art digital gadgets and services. This creates a digital divide within the education sector, these socio-economic disparities make it difficult to provide an equitable education system (Marinoni et al., 2020).

This article further argues that to remain relevant in the 21st century and those to come, educators must embrace technology and move with the times. Current educators could use AI to learn new technological skills that will make them embrace new mechanised teaching and learning pedagogies in the 4IR that is developing globally. Zimbabwe has to move together with the rest of the world to attain sustainable development. Skills required in all sectors of the economy are developed and taught by the education system. If the higher education system lags technologically, then all other sectors will probably suffer from a lack of relevant development-oriented skills.

Frey and Osborne (2013) asserted that about half of the jobs in the U.S.A. are at risk of automation in the future assuming that technological advancement continues at the current pace. This assertion sends a sombre message that educational systems have to evolve and advance to prepare graduates for the yet unknown future. AI will undoubtedly have a huge impact on future lifestyles and economies. Africa is largely lagging in the current global economic setup. The integration of AI systems in education can bridge the gap and bring Africa to par with the rest of the world. Africa has a chance to catch up with the rest of the world and move towards accomplishing the Sustainable Development Goals (SDGs) including the provision of quality education and the eradication of extreme poverty (UN, 2000; Boerean, 2019). This article asserts that integrating AI in higher education can foster development in Africa and stop the continent from being viewed by the world as the mainstay of poverty and underdevelopment. Given the vast natural resources available in Africa, an investment in technological advancement and the wide application of AI in education can transform the African continent into a global economic powerhouse.

Debate on AI integration in higher education

Participation in various National and International Conferences has led to the article writers' conclusion that Africa must invest more in research and that relevant authorities and stakeholders in education should source adequate funds to foster and advance technology development in the continent. It cannot be overemphasised that the development of AI systems is very expensive and requires a huge financial and technical knowledge input. The current secondary school education system in Zimbabwe is incorporating continuous assessment projects as part of the terminal assessment of learners. AI can be utilised to generate and grade assessment objectives of these learners very objectively and efficiently without teacher bias.

However, this anticipation for AI adoption may fail in economies and societies where a lack of digital

exposure and access to resources are inherent. Buttice(2019), and Mogaji & Jain (2020) argued that the application of AI needs an environment with highly developed data facilities and AI experts. Many African nations currently lack big data management systems. As asserted earlier on, data security is also a big concern in higher education in Africa. But this should not be a drawback, improvements can always be planned and implemented. Africa has, to date produced many engineers, technologists, educationists, computer experts….you name it. A way has to be found to harness this expertise to develop the continent (Autor,2015). This article triggers an academic debate on sustainable measures to be taken to reduce the brain drain that Africa is experiencing to reduce the underdevelopment bedevilling the continent. It won't come as a surprise to learn that some people who are developing AI systems in developed countries have their origins in Africa. Many African countries do not have enough regulations and legislature to guard against personal or private data abuse. Interestingly the African Union in 2014 urged African countries to enact robust cyber security measures but only a handful of countries have done so. This poses a drawback to the adoption of AI in education(Ochema,2018).

Many African countries like Zimbabwe have internet connectivity problems. AI relies on the availability of a stable internet connection, this is a big challenge to many rural settlements and some urban centres. The availability of electricity is also of concern. Investment in these areas is a pre-requisite for many African countries if AI is to be fully integrated into the higher education system. AI requires the use of machines with immense computing power. Many educational institutions in Zimbabwe, especially secondary and primary schools rely on donated computers that are mostly outdated and thus cannot handle the modern Information and Communication Technology (ICT) requirements. Modern computers and smartphones are very expensive for ordinary students and even for teachers and lecturers. This becomes a major challenge in the adoption of AI systems in the Zimbabwean context (Mogaji and Jain, 2020).

Ancient philosophers like Polanyi(1967) asserted that human activities and cognition are meaningful within a social and cultural background. If machines are to learn to act and respond like humans, whose culture will they follow? Which society will they mimic? These questions are of profound importance and require careful consideration. This might mean that whoever programs the machine will probably make it act and respond according to his or her cultural beliefs and norms. If the machines are designed, for example in Europe using European data then African students might not fully benefit from the personalised learning systems as they will not identify with them. This poses a challenge to African nations to come up with strategies to be part of the developmental stage of AI systems to integrate African norms and values into the AI systems. It would be unfortunate to make African learners change their identity to fit into the AI systems developed elsewhere. Another challenge is the presence of racial and ethnic discrimination in many African countries. The dominant race or tribe may detect the cultural values and norms embedded in the AI systems and exclude other minority or less dominant creeds, this may result in their utter rejection of the technology (Vincent and Van,2022).

Sample of Responses from a case study done in Zimbabwe

Question: How can Artificial Intelligence enhance quality education?

Responses were varied. Some mentioned the saving of time and empowerment of teachers and students. Some stated that AI can give teachers and learners a greater scope of their subject matter, the internet has more information on any subject or topic than any one human teacher. Some respondents argued that the personalised learning environment offered by AI systems is conducive for learners with special needs. These learners often need much individual attention which they cannot get in traditional physical classes. AI systems are also capable of suggesting methods of dealing with the disabilities or challenges that these students are facing.

Question: Routine tasks in education like marking registers, grading, and recording learners' work can be

quickly done by machines. To what extent do you agree with this assertion (be very brief)?

All respondents agreed with the assertion. Some cited that computer systems acting as humans may make errors in some predictions that may negatively affect students. This may occur if for example a system was designed in a setting that is very different from that in which the student or educator is operating, the system will use data fed to it which may not reflect the actual situation on the ground. This poses a challenge call for African programmers to come into the field of play. Respondents called for proper verification and validation checks and balances to be put in place to avoid a situation where students are given inaccurate or inappropriate content. Other respondents cited that several higher learning institutions in Zimbabwe are currently using generic web-based computer systems for grading purposes and lesson delivery using cloud storage.

From these responses, this article argues that individual HEIs should develop their own customised learning and grading platforms to cater to their particular students and educators.

Question: How do machines 'learn" to do certain tasks without much human intervention?

Quite a several responses thought that machines follow programs and can hardly learn anything on their own. Some people were sceptical and some did not believe that machines can learn on their own. These responses suggest a probable starting point in the integration of AI systems in education. Educators must be staff-developed and convinced that machine learning is happening in the world and AI is real and beneficial to the education system in Africa.

The slow uptake of AI technologies is partly due to the lack of adequate knowledge among educators. Some believe that machines can only do what they are programmed to do and cannot think or adapt to different environments or solve novel problems. This brings to light that many African educators are still in the dark, they still hold strongly to traditional teaching methods- a modern and futuristic model of teaching and learning needs to be unveiled to them.

Question: Which learning area can be taught more efficiently by machines than by humans?

Responses included the designing of projects and objects using computerised machines. This may lead to innovation and industrialisation due to the ability of machines to come up with a complete picture of the design before it is implemented. Corrections and modifications can be made before making the real object. If 3D printing is made available, many objects can be manufactured in the school system. Some educators posited that dangerous laboratory experiments can be safely modelled using AI. No one will physically touch any dangerous chemicals or objects yet they can experiment with or on them and get insightful results. Many schools in Africa with no proper laboratories or expertise can benefit from these virtual AI setups, albeit at a cost.

Question: What are the challenges that Africa is likely to face in fully implementing AI in her education systems?

Several challenges were cited including a lack of resources. These include both human resources in terms of expertise and financial resources to acquire the required machinery. These are challenges for many African countries given their poor economies. Some cited poor infrastructure to support AI systems, these included poor telephone networks and poor internet connectivity in many areas. Another challenge cited was technophobia. There are people, including those in influential decision-making positions who are adamant about change, they want to maintain the status quo and work within their comfort zones. The world is changing and so should the education system and all stakeholders involved. If Africa is reluctant to change, she risks continuing to follow behind others all the time in most aspects of life. Another challenge is that

people who get access to information available for machine learning may abuse it, this suggests that there must be a way to reduce the rampant corruption prevailing otherwise these AI technologies may end up being used for cyber-crimes instead of education. Some educators expressed fear that AI may create lazy students who will rush to computerised machines for answers to assignments and homework without thinking for themselves. This article poses this as a challenge to current and future educationists to seriously take into consideration and seek measures to eliminate.

Question: What opportunities can arise if AI is fully implemented in the education systems of Africa?

High speed and efficiency in doing work, especially routine work. Some people argue that globalization will be encouraged. The world education sphere would operate like one big classroom where students from different parts of the world would learn from one source without having to cross any physical boundaries. Collaboration among faculty and students would be much easier. This has the advantage of enriching the local education system by allowing those involved access to learning resources that are not locally available. Cutting down on physical interactions will greatly reduce the risk of transmitting commutable diseases among scholars. Another opportunity is that of giving students in Africa the much-needed 21st-century skills for survival in the modern global village.

At least at the moment, no one can claim to be a leader in AI technologies, Africa has an opportunity to take a brave step forward and invest in educational technology and avoid always coming from behind in developmental issues.

Technological infrastructural requirements for AI integration

Creating a conducive environment encourages innovative minds. This paper argues that given adequate infrastructural and human resource development, many African countries with an abundance of young and talented people can cultivate cutting-edge innovations including full AI adoption in all sectors of the economy. African nations are still struggling with infrastructural development. Most government policies concentrate on urban development while rural areas suffer. Government should ensure that they extend their developments to rural locations, bringing stable and adequate network coverage across all areas. In addition, the African Union and each respective African nation should establish robust AI strategies and policies that will be a foundation for the development and implementation of AI technologies (Okonkwo and Ade-Ibijola, 2023).

Insufficient Infrastructure and Network Connectivity

Inadequate infrastructure and the unavailability of affordable network coverage by the majority of people are some of the major impediments to AI adoption in Africa. The growth of infrastructural development as well as mobile technology network connectivity in Africa is slow (Marino Garcia and Kelly, 2020). A good percentage of Africa's population are either unconnected or do not have access to a fast and reliable internet connection. Adoption of AI requires adequate availability of wireless network connectivity. In some sectors where connectivity is available, people grapple with electricity power outages which render a double blow in the adoption of AI. Many African countries have the world's most expensive broadband. The Alliance for Affordable Internet (A4AI) reported that African countries inhabited nine of the ten least affordable spots in terms of internet access, with expenditures ranging from 12 to 44% of their Gross Domestic Product (GDP). This poses a challenge to educational institutions that are eager to integrate AI into their curricula (Marino Garcia and Kelly, 2020).

In a conference on AI, a top UNESCO official from Nigeria pointed out that while in some African countries, there are some Trusted Internet Connection (TIC) initiatives, the integration of AI in education is still in its infancy. It is disturbing, to say the least, that in a continent with a large pool of young people,

about 90% of secondary school students leave school without having learned the rudiments of computing, and sometimes without having used a computer. This suggests that the procurement of computers and other digital gadgets needs to be done expeditiously and given top priority in the education sector if Africa needs to catch up with the rest of the world in harnessing the power of AI (UNESCO, 2019).

Connectivity issues

For AI to be successfully integrated, Africa has to greatly improve its connectivity issues. The World Bank's Digital Economy for Africa (DE4A) made commendable strides to improve access to broadband in Africa from 26% in 2019 to 36% in 2022. Unfortunately, only about 36% of the continent's population has access to broadband internet services. Download speeds are relatively lower in Africa although, in 2019 DE4A launched developments which increased download speeds to about 8.18megabits per second (8.18Mbps). Many African countries including Zimbabwe still grapple with sound infrastructural development in internet services, particularly in remote rural areas where the bulk of the population resides. Massive investment is needed in educating people on the importance of AI and to lay strong foundations for the digital economy and robust reforms by policymakers to develop enabling policies and regulatory frameworks that encourage investment and effective utilisation of digital infrastructure (World Bank, 2023).

Software requirements and platforms necessary for effective AI integration in Africa

AI in education is essentially dependent on the ability of humans and machines to interact and communicate effectively. This paper argues that computers and all other digital systems mostly use binary mathematics to process information. It would be too much to ask non-computer science students and lecturers to learn binary mathematics and Boolean algebra to communicate with machines. It is therefore imperative to teach machines human language. The concept of machine deep learning comes into effect. Computerised machines can use complex algorithms and neural networks to learn natural human language and thus can effectively communicate with students and teachers who may not know anything about Boolean algebra. This is a sub-field of AI called Natural Language Processing (NPL). Computer systems can access information from the cloud and process it to create personalised teaching and learning content, thus can act as chatbots (also called virtual assistants) in various subject matter. Programmers from Africa need to come on board and actively avail large amounts of information about African learning curricula and on personal academic attributes of African students so that AI systems can pick up this information and provide personalised learning systems for African students. This paper further posits that many students in Zimbabwe especially in rural areas do not perform well in academics because they are grappling with many challenges simultaneously, like lack of access to digital resources, learning their various subjects in a language foreign to them, learning STEM subjects with no access to equipped laboratories and so on. This paper challenges relevant stakeholders of education in tertiary institutions in Africa to change the status quo. AI systems can be made to learn African languages if provided with enough information (Han & Lee, 2022; Pérez et al., 2020).

NPL applications like Duo Lingo and Babbel employ AI to provide interactive language instruction using human speech recognition and language competence assessment to provide personalized feedback to help learners improve their language skills. The languages in question here are those of the global North. The question is, 'Who or what will assist the African student to be competent in their language?' NLP allows AI systems to generate human-like language and facilitates the creation of educational materials, explanations, and feedback, generating written explanations of complex phenomena in a learner-specific manner in a natural human language format (Jurafsky, Martin, 2008).

By leveraging the NLP capabilities of AI-powered educational applications, coupled with the data mining abilities of AI systems students can have more interactive and personalized learning experiences. At the same time, educators can benefit from objective automated grading of learners' assignments, efficient

feedback generation, and virtual colleagues who can give insightful ideas to improve their practice. AI-based grading systems, such as Grade Scope or Turnitin, utilize NLP and machine learning to assess and provide feedback on student assignments, including grading some subjective work like essays using applications like the E-rater system. These systems can save time for educators to concentrate on more cognitively challenging aspects of their work that require much critical thinking like research and the generation of innovative ways of teaching. Learners also benefit from obtaining instantaneous feedback and implementing corrective measures while the learning content is still fresh in their minds (Heilman & Madnani, 2015:55-67; Barnes, 2019; Johnson et al., 2016).

Examples of AI software applications that can be utilised from secondary school up to tertiary education in Zimbabwe include Brainy, Dreambox, SMART learning suite, Nearpord, Nexia, Power School and Class craft. These applications provide an interactive learning environment and some gamification to assist learners in grasping educational content in a friendly and less formal manner.

Cloud computing

These data storing, processing and retrieval services are increasingly being provided using Internet technologies to staff and students and accessed from web browsers. Cloud computing allows the storage of large volumes of information which are essential for AI to thrive and may not be easily stored in physical devices like hard drives, disks and flash drives (USBs). The tremendous amount of information available on the cloud is often much more and is of a higher quality than what can be provided by any given educational institution. Popular Service providers like Microsoft and Google provide many such services for free or can be purchased by institutions or groups of institutions by pooling resources together and used freely by students and faculty. Of course, data security issues have to be developed to protect people's private information details against cyber criminals. This is also one area Africa needs to invest in to fully utilise AI-powered education systems (Educause, 2010; Huth and Cebula, 2011; Armbrust et al., 2009).

Virtual platforms required for effective AI integration

An intelligent tutoring system (ITS) which utilises computer systems and cloud computing technologies needs to be developed and employed to provide a mechanised teaching platform with learner-customised content capable of giving instant feedback and assessment of learners mostly without human-teacher involvement. The computer system needs to pass the Turing test discussed in some sections of this paper. ITS systems require powerful high-speed computer systems and multi-sectoral synergies among different professionals like psychologists, and teachers. And computer technicians and software engineers. Zimbabwe and Africa in general need a large financial and technical boost to develop these systems (Psotka and Mutter, 1988; Arnau-González, Pablo; Arevalillo-Herráez, Miguel; Luise, Romina Albornoz-De; Arnau, David (2023-06-01).

Effective Learning Management Systems (LMS) like Moodle, Canvas, and Blackboard platforms often incorporate AI-powered features that include personalized learning paths, intelligent recommendations for example on further study opportunities, institutions to attend, measures to improve academic performance and automated grading. AI-powered recommendation systems, such as Netflix and YouTube algorithms can be used to suggest relevant learning resources, educational videos, and recommended readings based on individual preferences and learning history. Access to LMS systems requires a very fast, stable and reliable internet connection.

Virtual Learning Environments (VLE) like Google Classroom/Google Meet, Zoom, and Microsoft Teams and social platforms like WhatsApp, Facebook, and Twitter(X) provide digital spaces for teachers and students to collaborate remotely, share resources, and engage in online learning activities. AI can be integrated into these platforms to provide a quality education experience including simulating experiments

or excursions that cannot be easily carried out physically.

Hardware requirements

It goes without saying that to achieve AI integration suitable hardware and devices that are capable of connecting to the internet and are also compatible with the software applications are required otherwise it would be futile to have high-quality AI systems and yet be unable to utilise them.

This paper strongly emphasises investment in powerful internet servers and cloud-based infrastructure at the national, regional or district level so that all educational institutions within that area can access high-quality and fast internet services at low cost. Educational institutions or individuals can seek donor funding or engage in partnerships to acquire modern high-performance computing devices (HPC) like laptops, personal computers, smartphones and tablets because modern AI tools use algorithms and software packages that require very powerful machines with high processing speeds to function effectively. Zimbabwe and the rest of Africa need to locally produce a highly skilled labour force in computer programming and related fields to ensure that the great number of mobile devices entering the continent from the global North are compatible with local systems and also capable of accessing the rich internet services available on the global market. Frequent upgrades need to be done on some hardware and software applications and it would be very expensive to keep on hiring foreign experts for their services.

Notable AI developments in Africa

This paper highlights the successful utilization of AI technology in certain African countries despite the challenges faced by the continent. To promote further AI development, it is recommended that African nations establish strong collaborations and resource-sharing arrangements. For instance, Zimbabwe could benefit from learning from these countries and enhancing its Education 5.0 policy by embracing AI-driven innovation.

Consider Uganda's mobile app for diagnosing malaria or Nigeria's text-reading pen. These inventions could greatly impact education if they are further developed and marketed globally. Similarly, Côte d'Ivoire's solar pack designed for charging phones could be expanded to include charging other digital devices, which would be highly beneficial in Zimbabwe's urban centres and remote areas. Africa's sunny climate makes solar systems an ideal green energy solution. Additionally, drones initially developed for agricultural use by farmers could be repurposed for geographic studies and enhance the education curriculum. Congo's first African-made smartphone and Ethiopia's chatbot 'Sophia' demonstrate the potential of young people in Africa to drive the AI revolution. To create an enabling environment, policymakers must prioritize high-quality education, public-private sector partnerships, and inter-continental and global collaborations. (UNESCO, 2019: 32-35).

Tapping Locally Available Resources

It is very important for educational institutions to critically assess their existing technological infrastructure (both hardware and software), identify gaps, and carefully plan for necessary upgrades or investments to support the effective integration of AI in education settings. Collaborations and consultations with local and global technology experts can be insightful and beneficial in coming up with effective strategies to design, develop and implement the required technological infrastructure for successful AI integration in education. AI integration also requires readily available personnel who can provide continuous monitoring, maintenance, and support systems to ensure the smooth functioning of AI systems and to resolve any technical issues encountered by students and faculty within a very short period. This calls for local human resource capacity building because it would be very expensive and time-consuming to rely on hiring

someone who is not based locally and may not fully understand the local settings (Microsoft, 2018).

CONCLUSION

This paper advocates that AI systems offer the opportunity to drive innovation. Educators, researchers, and learners can leave routine and predictable tasks to machines and concentrate on highly cognitive areas. This will enhance innovation and the massive industrialisation in the African continent. The current philosophical thrust in Zimbabwean education is Education 5.0 which promotes Industrialisation and Innovation. Institutions in Higher Education have established Innovation hubs and Industrial parks. These can greatly benefit from the adoption of AI technologies.

A study by this paper has shown that many educators in most universities in Zimbabwe are unaware of the potential of AI to revolutionise and improve the local education sector. Some believe that the integration of AI into the Zimbabwean education system is a pipe dream. This is unfortunate given the global advances in technology and the power of AI technologies. These sentiments show that a lot of education and professional seminars have to be organised to make educators and the public aware of what the future world might be like and prepare for it in advance.

It cannot be overemphasized that in the future many tasks currently performed by humans will be done by machines. Humans therefore should upskill and be prepared to do jobs that do not exist at the moment. This can only be achieved by revolutionizing the education sector. If African education systems fail to embrace the advances in technology, many graduates churned out will be unfit for the world to come. With a focus on the needs of modern learners and faculty, the education sector can create a more equitable, effective, and sustainable learning environment by leveraging the power of AI to advance education in all its forms.

By addressing the challenges and limitations discussed, HEIs can maximize the potential of AI and use it responsibly and ethically to enhance teaching and learning experiences.

RECOMMENDATIONS

For higher educational institutions (HEIs) contemplating the integration of AI technology, a critical first step is to assess their current infrastructure and resources. This evaluation should encompass both human resources, such as staff skills and knowledge, as well as material resources, including technology and hardware. Once HEIs have a clear understanding of their existing resources, they should explore collaborating with external funders and AI system experts to determine how best to maximize their current resources and make any necessary additions or adjustments. This could involve enhancing or upgrading existing technology, hiring specialized staff, or creating new training programs to improve the skills of current employees. By taking these measures, HEIs can significantly reduce the cost of acquiring a new AI system while still leveraging its many benefits. Moreover, by working with outside experts, HEIs can ensure that they are implementing the most effective and efficient AI system tailored to their specific needs and goals (Ndofirepi et al., 2020).

Ongoing dialogue and collaboration are pivotal among educators, technology experts, and higher education policymakers to develop effective strategies and solutions tailored to the unique needs of different communities and institutions. It is also important to ensure that the internet services are of high quality and capable of meeting the demands of modern education – integrating AI systems by investing in infrastructure upgrades, improving network security measures, and providing adequate technical support and training to users (Fitzharris & Kent, 2020; Ungerer, 2019).

It is crucial for educators to feel empowered to explore the latest and most innovative technologies. One

effective way to increase their confidence is through support structures provided by colleagues and leaders, such as comprehensive training manuals on AI applications, staff development webinars, seminars, and workshops. Equipping faculty with the necessary technology skills will encourage them to embrace AI and, in turn, inspire their students to do the same. Ultimately, this will lead to the seamless integration of AI in higher education institutions.

To facilitate the quick integration of AI in higher education, professional development programs should be strengthened in teacher training colleges and universities. This will ensure that graduates possess the technical expertise required to adopt and utilize emerging technologies like AI in the teaching and learning process. By increasing their confidence in applying AI, this approach will also reduce the time spent on learning new technologies while on the job (Cheok, et al., 2017).

For AI integration to succeed, African governments must revise their policies and provide conducive environments for educationists to research freely and come up with innovations that can provide sustainable development. At the moment only a few African countries like Kenya. South Africa, Ethiopia, Nigeria, and Ghana have laid down a solid foundation for the integration of AI into their education systems. These countries have established collaborations with global players in the fields of education and technology. This highlights an important fact that to achieve sustainable development in any country, partnerships with other more developed players are pivotal (Nayebare,2019).

Students need to embrace the various forms of AI available across different platforms and build relationships with both technology and their human teachers. AI systems can provide quick and accurate access to vast amounts of information, and can even develop an understanding of individual students based on their interactions with the system. This allows for personalized learning that can adapt to the student's pace and cognitive level. By working together with AI, students can greatly enhance their knowledge acquisition and retention in various subject areas and at different academic levels. In today's fast-paced world, students need to adapt to the various forms of AI available across different platforms and build healthy relationships with both technology and their human teachers. AI systems can provide students with quick and accurate access to vast amounts of information, and can even develop a deep understanding of individual students based on their interactions with the system. This allows for personalized learning that can adapt to the student's pace and cognitive level, ultimately leading to greater knowledge acquisition and retention. By embracing the potential of AI, students can significantly enhance their academic performance and stay above the learning curve in various subject areas and at different academic levels. (Riedl, 2019).

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