Harnessing Artificial Intelligence for Advancing Sustainable Development Goals in South Africa's Higher Education System: A Qualitative Study

Oluwaseyi Aina Gbolade Opesemowo[*] 🆔
Department of Science and Technology Education
Faculty of Education
University of Johannesburg
Johannesburg city, South Africa

Victoria Adekomaya 🆔
Department of Business Management
College of Business and Economics
University of Johannesburg
Johannesburg city, South Africa

Abstract. Artificial intelligence (AI) presents opportunities in transforming higher education system and contribute significantly to achieving Sustainable Development Goals (SDGs). This study seeks to leverage AI technologies to advance SDGs within South Africa's higher education system. It examines AI technology adoption in South African higher education institutions and challenges, strategies, and potential future directions. This qualitative research employed the constructivist principle to unravel the dynamics of AI in advancing SDGs in South Africa. Lecturers from the Department of Information Sciences were the participants of the study. The participants were purposefully selected based on their experience and knowledge of AI technologies. In-depth interview and focused group discussion was employed to generate and estimate responses using thematic content analysis. The result revealed that participants used AI technology to increase students' learning and engagement so students would not doze in class. It was discovered that AI technology has increased the chances for collective learning. The study further proved that AI technology can improve personalized learning experiences of students with diverse learning styles and abilities. This has led to a more inclusive and interactive classroom environment where students feel more motivated and supported in their learning journey. Integrating AI technology into education has shown promising results in improving student outcomes and fostering a more collaborative learning

[*]Corresponding author: *Oluwaseyi Aina Gboade Opesemowo*; *oopesemowo@uj.ac.za*; *opesemowoo@gmail.com*

atmosphere. Based on the results, it implies that harnessing AI would advance SDGs in South Africa's higher education institutions. As such, we recommended that the South African government should formulate comprehensive national AI education policy guidelines for higher education to regulate and harmonize the usage of AI in the higher education system.

1. Introduction

Artificial intelligence (AI) stands poised as a transformative force capable of reshaping various sectors, including education, towards achieving Sustainable Development Goals (SDGs). In the context of South Africa's higher education system, the integration of AI technologies holds significant promise for advancing academic pursuits and sustainable development objectives. This qualitative study explores the intricate relationship between AI adoption and its potential to drive progress towards SDGs within South Africa's higher education landscape. As South Africa grapples with socio-economic challenges and strives to meet its sustainable development targets, the role of higher education institutions becomes increasingly pivotal. South Africa's higher education system is characterised by its diversity and complexity, reflecting its historical and social dynamics (Goralski & Tan, 2020; Perumal, 2010; Pinheiro et al., 2012). It comprises many public and private institutions, each with its unique mission and focus. South Africa boasts a variety of higher education institutions, including universities, universities of technology, and comprehensive universities, each catering to different academic and vocational needs (Pedro et al., 2019; Schwartzman, 2015). The higher education system has been shaped by the country's apartheid history, leading to disparities in resources and access (McKeever, 2017; Mzangwa, 2019). The legacy of apartheid has left a lasting impact on the demographic composition of students and faculty. While significant progress has been made in increasing access to higher education, racial, economic status, and geographic location disparities persist. There are ongoing efforts to address these inequalities. South African universities have a history of international collaboration and are recognised for their research output and academic contributions. Many universities actively engage in international partnerships and alliances.

The South African government is crucial in promoting AI for the SDGs by investing in research and development initiative (Brand, 2022; Wakunuma et al., 2022). The South African government is dedicated to exploring how AI can address various social and economic challenges in the country. As a result, President Cyril Ramaphosa introduces the fourth industrial revolution into his national economic strategy upon assumption of office in 2018 (Sutherland, 2020). Also, the government collaborate with universities, research institutions, and private sectors in ensuring the drive for innovations and create solutions that can positively impact the lives of its citizens. By fostering a supportive environment for AI development, South Africa is positioning itself as Africa's leader in using

advanced technology for sustainable development. This commitment to harnessing AI for SDGs is evident in initiatives such as improved education and healthcare. Despite this gain, the South African higher education system faces funding constraints, student protests, curriculum transformation, and addressing historical injustices (Sivanath, 2020). These issues have led to ongoing debates and reforms within the system. The United Nations Sustainable Development Goals (SDGs) are set of 17 global objectives aimed at focusing on diverse social, economic, and environmental challenges by 2030 (Boluk et al., 2019; Carpentier & Braun, 2020; Halkos & Gkampoura, 2021; Tsalis et al., 2020). These goals are particularly relevant to South Africa for several reasons. For various reasons, including considerable social and economic inequities, these goals are fundamental to South Africa, and the SDGs provide a framework for decreasing poverty, promoting gender equality, and ensuring access to quality education and health services for all citizens. Also, the country is significantly reliant on natural resources, and the SDGs place a premium on sustainable resource management and environmental conservation, both of which are critical for South Africa's long-term development.

South Africa is known for its significant income inequality, and several SDGs, including SDG 1 (No Poverty) and SDG 10 (Reduced Inequalities), directly address economic disparities (Butcher et al., 2021). Achieving these goals is essential to improving the overall well-being of all South Africans. Given the historical and educational challenges, SDG 4 (Quality Education) is paramount to South Africa (Mhlanga, 2021a; Opesemowo, 2023). The country is committed to providing inclusive and quality education at all levels, addressing issues related to access, retention, and learning outcomes. SDG 3 (Good Health and Well-being) is critical in South Africa, where health disparities and challenges associated with HIV/AIDS, tuberculosis, and other diseases persist (Nkosi, 2019). Achieving this goal is vital for the general development and well-being of the population.

Currently, like any other Africa countries, South Africa faces environmental challenges, including pollution and water scarcity. SDG 7 (Affordable and Clean Energy) and SDG 6 (Clean Water and Sanitation) are essential for sustainable development in the country. South Africa continues to grapple with issues related to gender-based violence and gender disparities in various sectors. SDG 5 (Gender Equality) emphasises the importance of gender equity, which is highly relevant to South Africa's social development (Vincent et al., 2023). South Africa recognises the importance of international collaboration and partnerships (SDG 17) in achieving the other SDGs. The country actively engages with international organizations and stakeholders to achieve common goals. Mbiza and Sinha (2023) mentioned that the SDGs are closely aligned with the challenges and aspirations of South Africa. The country's commitment to achieving these goals is reflected in its policies, programs, and efforts across various sectors, including education, health, environment, and social development. Achieving the SDGs is crucial for advancing sustainable development and improving the quality of life for all South Africans.

1.1 Problem Statement

South Africa's higher education system stands at a critical juncture where it faces numerous challenges in achieving the United Nations SDGs, particularly quality education, equity, and lifelong learning. The emergence and potential of Artificial Intelligence (AI) offer promising solutions, but a pressing problem exists. South African higher education institutions effectively harness and integrate AI technologies to address the multifaceted challenges of providing equitable access to quality education, supporting lifelong learning, and aligning with SDGs within the South African socio-economic and educational context. South Africa's higher education system faces challenges with access to quality education. Marginalized communities often lack equal opportunities for quality education. AI offers a possible solution, but the problem lies in how to implement AI to bridge these disparities effectively.

South Africa is committed to achieving the SDGs, with SDG 4 (Quality Education) and other related goals as top priorities. The problem is leveraging AI within higher education to contribute to these objectives substantially. Historical inequalities and socio-economic disparities impede equitable access to quality education. Implementing AI must ensure it does not exacerbate existing disparities but facilitates inclusive and equitable educational opportunities. Integrating AI in education raises ethical issues related to data privacy, algorithmic bias, and the potential displacement of human educators. These ethical dilemmas must be addressed effectively. South African higher education institutions often grapple with resource limitations, including budget constraints and a shortage of educators. The problem is how to implement AI solutions within these resource constraints. Implementing AI in education often encounters resistance from stakeholders. Addressing this resistance and fostering a culture of innovation is a significant challenge. There is a lack of comprehensive guidance and best practices for South African higher education institutions on how to effectively harness AI for sustainable development in alignment with SDGs.

Resolving this problem is of utmost importance for South Africa's higher education system, as effectively harnessing AI can lead to substantial advancements in quality education, equity, and lifelong learning. It will require a multidisciplinary approach involving educators, policymakers, technologists, and stakeholders to collaboratively develop strategies and solutions that address these challenges and lead to the meaningful integration of AI in South African higher education to advance SDGs. To our knowledge, several studies have been conducted on AI technologies to address SDG-related issues. Still, there has been a drought of research on this topic, which predominantly lies in the lack of comprehensive exploration of lecturers' perspectives within the South African higher education context. This study aims to address this gap by conducting a qualitative investigation that delves deeply into the nuances of the AI technologies adopted in South African higher education institutions, ascertain how AI affect the advancement of SDGs in South African education, and the primary challenge higher education institutions in South Africa faced when implementing AI technologies. From the objectives of the study, the following research questions were formulated.

1. To what extent have AI technologies been adopted in South African higher education institutions?
2. How does AI affect the advancement of SDGs in South African education?
3. What primary challenges do higher education institutions in South Africa face when implementing AI technologies?

2. Related Work

AI imitates human intelligence in machines, permitting them to execute tasks that typically require human acumen (George & Wooden, 2023). These tasks involve learning, reasoning, problem-solving, understanding natural language, and adapting to new information. AI systems are designed to process large amounts of data, recognise patterns, and make decisions based on their analysis. In the education framework, AI technologies aim to augment and personalise learning experiences, streamline administrative tasks, and provide valuable insights to educators and students (Gupta et al., 2023). AI has gained prominence worldwide in education, offering various applications and benefits. AI's role in education continues to evolve, with innovative applications and research projects driving its integration into classrooms and online learning environments (Bozkurt et al., 2021; Kuleto et al., 2021; Mbiza & Sinha, 2023). The use of AI technologies in education is expected to expand further, offering the potential to enhance the quality, accessibility, and inclusivity of education on a global scale.

2.1 How AI Can Improve Access to Education (SDG 4)

AI can play a crucial role in improving access to quality education, particularly in Sustainable Development Goal 4 (SDG 4), which aims to ensure inclusive and equitable quality education for all (How et al., 2023; Opesemowo & Ndlovu, 2023). AI-powered platforms and virtual classrooms enable students to access educational resources and participate in courses online, reducing geographic barriers to education (Chakroun et al., 2019). This is especially important in areas with limited access to schools or universities. Okewu et al. (2021) state that AI-driven adaptive learning systems can tailor educational content and pace to each student's needs and abilities, making education more accessible to diverse learners, including those with different learning styles and paces. AI can identify students at risk of falling behind or dropping out, allowing timely interventions to keep them on track (Fan et al., 2023). AI-powered learning analytics can help educators track students' progress in real time. This information can be used to adapt instructional strategies and interventions to maximise learning outcomes. AI can create adaptive learning pathways that adjust the pace and complexity of lessons according to the individual needs of each student, helping them reach their full potential (Chakroun et al., 2019).

2.2 Personalised Learning and AI-Based Assessments (SDG 4)

Personalised learning and AI-based assessments are crucial components of enhancing the quality of education, as outlined in SDG 4 (Gwagwa et al., 2021). AI allows personalised learning experiences by tailoring educational content and pacing to individual student abilities and learning styles (Alam & Alam, 2021; Chakroun et al., 2019). This approach can ensure that students are challenged appropriately and receive the support they need to succeed. These platforms

adjust lessons' difficulty levels and content in real time, offering customised learning experiences. For example, a struggling student may receive additional practice on a particular concept, while an advanced student may move on to more challenging material. De Villiers et al. (2021) mentioned that AI-driven assessments can identify students' competencies and gaps in knowledge. Competency-based education models allow students to progress at their own pace and move to higher levels of education when they demonstrate mastery. AI-based assessments provide instant feedback to students, helping them understand their strengths and areas that need improvement (Alam, 2023; González-Calatayud et al., 2021; Vittorini et al., 2021; Zhou & Etzkowitz, 2021). This rapid feedback loop enhances learning outcomes by reinforcing correct answers and addressing misconceptions promptly. AI-based assessments and grading systems reduce the administrative burden on educators, allowing them to focus more on teaching and providing personalised student support (De Villiers et al., 2021). AI-based assessments can be scaled efficiently to accommodate large numbers of students, making them a cost-effective solution for evaluating and improving the quality of education (Gwagwa et al., 2021). By incorporating personalised learning and AI-based assessments into schooling, educational institutions can better align their teaching methods with students' needs, resulting in higher quality education experiences and improved learning outcomes, ultimately contributing to the fulfilment of SDG 4.

2.3 Addressing Gender Disparities in Education Through AI (SDG 5)

Sustainable Development Goal 5 (SDG 5) aims to achieve gender equality and empower all women and girls. AI can address gender disparities in education by promoting equal access, participation, and opportunities (Shiohira, 2021). AI algorithms can identify and rectify gender biases in educational materials, ensuring that textbooks, online resources, and curricula promote gender equality and do not perpetuate stereotypes (Baker & Hawn, 2022; Opesemowo & Ndlovu, 2023; Saeidnia, 2023; Vincent et al., 2023). AI-powered adaptive learning platforms can tailor educational content to girls' individual needs and learning styles, helping them overcome potential disparities in academic achievement (Zeleza & Okanda, 2021). AI-driven chatbots and virtual mentors can guide and support female students, addressing questions and concerns about their educational and career paths (Akgun & Greenhow, 2022; Pedro et al., 2019).

AI can facilitate the creation of gender-neutral, accessible learning environments that accommodate the needs of girls and women, including those with disabilities or those facing socio-economic barriers. AI can help institutions collect and analyze data on gender disparities in enrollment, retention, and academic achievement. This data can inform policies and interventions to reduce gender gaps (Shiohira, 2021). AI-driven language translation and support tools can help girls who may not speak the language of instruction to access educational content in their native languages. AI can provide tailored career advice and pathways, encouraging girls to explore traditionally underrepresented fields and make informed decisions about their education and careers.

2.4. AI to Bridge Educational Inequalities in South Africa (SDG 10)

Sustainable Development Goal 10 (SDG 10) focuses on reducing inequalities within and among countries. In South Africa's education context, AI can play a pivotal role in bridging educational disparities and ensuring all students have equitable access to quality education (Mhlanga, 2021b). AI can offer tailored educational content, allowing students from diverse backgrounds to learn independently. This personalisation is especially beneficial for students struggling in traditional one-size-fits-all classrooms. AI can enable students in underserved or remote areas to access high-quality educational resources and participate in online courses, reducing geographical disparities in education (Goralski & Tan, 2020).

AI can support digital literacy programs to equip students with the necessary skills to use technology effectively, ensuring that no one is left behind in the digital age (Zeleza & Okanda, 2021). AI-driven early warning systems can identify students at risk of falling behind or dropping out, enabling timely interventions to support vulnerable populations and reduce educational inequalities (Makala et al., 2021). AI can assist educational institutions in optimising resource allocation, ensuring that funding and support reach underserved schools and communities, thereby decreasing resource-related inequalities (Gupta et al., 2023). By adopting AI technologies while keeping inclusivity as a core principle, South Africa can leverage AI to bridge educational disparities, ensuring every student has an equitable opportunity to access quality education and reducing inequalities as outlined in SDG 10. AI is rapidly transforming the landscape of education globally, offering innovative solutions to address the complex challenges higher education institutions face. In South Africa, a country dedicated to achieving the United Nations Sustainable Development Goals (SDGs), integrating AI in higher education holds significant promise for advancing these goals (Zeleza & Okanda, 2021).

This literature review provides an overview of the current state of AI integration in education, with a specific focus on South Africa, and explores the potential of AI to contribute to SDGs within the country's higher education system. Research demonstrates the increasing use of AI in education worldwide. AI-powered technologies, such as intelligent tutoring systems and personalised learning platforms, have been shown to enhance student outcomes, improve retention rates, and provide adaptive learning experiences (Makala et al., 2021). These global developments set the stage for South Africa's exploration of AI in education. South Africa's higher education system faces numerous challenges, including disparities in access, limited resources, and historical inequalities. These challenges are closely linked to the SDGs, particularly SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities) (Kim & Shin, 2021). AI offers the potential to address these challenges, but the effective integration of AI requires careful consideration. Research emphasises the role of AI in improving equity and access to quality education. AI-driven solutions can offer personalised learning experiences and educate underserved communities through online and distance learning (Mhlanga, 2021a). These innovations align with SDG 4 and SDG 10, ensuring no one is left behind. The ethical implications of AI in education are a growing concern. Data privacy, algorithmic prejudice, and possible displacement

of human educators are all issues that must be carefully considered (Carpentier & Braun, 2020).

South African higher education institutions are increasingly exploring AI applications. Case studies of AI initiatives in South African universities, such as using chatbots and AI-driven student support systems, demonstrate their potential to improve student experiences and outcomes (Carman & Rosman, 2023). South African institutions often grapple with limited resources and budget constraints. Effective AI integration must navigate these limitations and address resistance to change and digital infrastructure gaps (Makala et al., 2021). Research in the global context emphasizes the importance of developing comprehensive guidelines and recommendations for effective AI implementation in education (Mhlanga, 2021a). Such procedures ensure that AI adoption aligns with the country's SDG commitment. The literature reviewed underscores the potential of AI to significantly contribute to the advancement of SDGs within South Africa's higher education system. It reveals a growing global trend of AI integration in education, with case studies demonstrating its impact. However, the unique challenges and opportunities in South Africa must be considered. Ethical concerns, resource limitations, and the need for equity and access make it imperative to develop guidelines for responsible AI implementation in higher education, aligning South Africa's educational system with its commitment to SDGs.

3. Materials and Methods

This qualitative research methodology unravels the complexity of harnessing AI to advance the course of SDGs within South Africa's higher education system. The study design adopted a constructivist principle to uncover the intricate dynamics between AI deployment and SDGs in South African higher education. Constructivist principles are foundational in qualitative research, influencing the understanding of knowledge acquisition, reality perception, and the interpretation of experiences within a research context. Constructivist concepts stress that humans actively generate knowledge rather than passively receive it from the outside world (Mohajan & Mohajan, 2022). The participants of this study were the lecturers from the Department of Information Sciences under the Faculty of Science. The lecturers were selected based on their expertise and experience incorporating technology and AI tools into their teaching practices. The participants consisted of three male and two female lecturers, all within the Department of Information Science, who provided an in-depth view of the three themes that guided the study. Through in-depth interviews and audio recordings, five lecturers from the Department of Information Science were surveyed purposefully to gather insights into their experiences and perceptions regarding the use of technology in teaching. The survey included questions about their preferred technological tools, challenges faced in implementing technology, and the benefits they observed in student learning outcomes. The interview results were presented thoroughly, highlighting the essential findings and insights gained from the participants. The researchers ensured that the presentation was organized and easy to follow, allowing the participants to grasp the significance of their contributions fully. Also, as the session progressed, it became evident that the participants' perspectives provided a rich and diverse understanding of the

themes that guided the study. Thematic analyses were used to distilled patterns and insights from qualitative data, offering a deeper understanding of AI implementation's challenges, opportunities, and impacts on SDGs in South African higher education. The collected data were from 13th October to 12th November 2023. The research strives to provide nuanced insights into how AI can be harnessed to promote sustainable development within the country's education landscape, offering valuable guidance for future initiatives and policies while maintaining ethical considerations. Ethical considerations and triangulating the responses allowed the researchers to perform validity and reliability checks to ensure data credibility and accuracy of identified themes, challenges, and future directions. The respondents willingly participated in the study, and their consent was granted prior to gathering the data and assurance about their confidentiality was prioritised.

4. Results
Results were presented according to the sequence of the research questions formulated in the study. Furthermore, themes were used in the results to disclose the insights, experiences and perceptions of the participants regarding the use of technology in teaching.

4.1. Extent of AI technologies adopted in South African higher education institutions.
AI technologies have been adopted to a significant extent in South African higher education institutions. Using AI technologies in higher education has developed more efficient, adaptive, and effective educational models than traditional methods. This has made teaching and learning more engaging and interactive and has improved learning outcomes. AI technologies have been applied to various tools and assessment platforms to aid skill development and close the lacuna in teaching and learning.

Theme One: Use of AI technologies in higher education.

This theme addresses the use of AI technologies in higher education, exploring the potential benefits and analysing students' data using AI algorithms.

Participant Three said I use AI technology to enhance student learning and engagement. Yooo!!!, I realised that prior to the advent of the new technology, some students got bored, making them doze in class. Using technology in learning is good for engaging students, and adopting technology was the right step in the right direction. However, AI technology in education has transformed students' learning by providing individualized and adaptable learning experiences. These tools can analyze students' performance and provide real-time feedback, enabling educators to address individual needs efficiently. Students can better navigate the digital world and learn crucial abilities for future employment when AI is adopted in the classroom. *Ehis!!! Some AI technologies I have utilized include virtual reality simulations and personalized learning platforms. These tools allow me to create immersive and interactive learning experiences for my students*. Additionally, *AI-powered chatbots and grading software help streamline administrative tasks, giving me more time to focus on providing individualized support to my students. Integrating AI technologies into my*

teaching has drastically transformed how students learn and improve their academic outcomes, Participant Four noted.

The use of virtual reality simulations has been particularly impactful in my classroom. By immersing students in realistic scenarios, students can actively participate in their learning and gain a deeper understanding of complex concepts. The students are more engaged and excited to learn using virtual reality simulations. This technology allows for interactive and hands-on experiences that traditional teaching methods cannot match. The students can explore students can explore subjects more effectively, leading to increased retention and understanding of complex concepts for students, as reported by Participant Five. For example, in a biology lesson, students can explore the human body in a virtual environment, dissecting organs and observing how they function in real time. This hands-on approach not only sparks their curiosity but also allows them to make connections between theory and practice. Moreover, personalized learning platforms have revolutionized the lecturers deliver instruction. These platforms use AI algorithms to analyze student data and tailor content to their needs and preferences. This level of personalization ensures that students receive instruction targeted explicitly at their strengths and areas for improvement. It also provides instant feedback to students so they can track their (students) progress and adjust their learning strategies accordingly. An individualized learning experience enhances the engagement and motivation of students. *Participant Four testified that incorporating technology into the classroom has increased the opportunities for collaborative learning. Students may easily interact and collaborate with friends, even if they are in different locations, using technologies like online discussion boards and video conferencing*. This develops a sense of community and enables the exchange of ideas and points of view. Finally, technology in education has altered the learning experience by allowing students to engage in interactive and personalized learning while encouraging teamwork and communication skills.

Subsequently, using technology, lecturers can now create personalized learning experiences for each student. Lecturers can personalize classes to individual students' needs and interests using internet platforms and educational apps. This personalized learning technology allows students to continue learning at their own pace, ensuring they thoroughly understand the topic before moving on. Likewise, technological advancements have opened a world of resources and information for students to explore. *Yoo!!! It is now possible for students to perform in-depth research and expand their knowledge beyond what can be provided by traditional textbooks by accessing a wide variety of online libraries, databases, and research materials with just a few clicks Participant Five highlighted.*

4.2. How does AI affect the advancement of SDGs in South African education

AI has the potential to address challenges in South African higher education and contribute to the advancement of SDGs. It can innovate teaching and learning methods, aid skill development, and improve the quality of the education system.

Theme Two: Contributions of AI in the advancement of quality education

This theme focuses on the ample contribution of AI technology in advancing quality education in South African higher education.
Some lecturers were interviewed to establish their observations and identify the substantial contribution of AI technology to the advancement of quality education in South Africa. *Participant Four believed AI is essential in advancing SDGs in South African education.* AI can provide students with personalised learning experiences, regardless of where they are located, thereby improving the quality of education. In addition, *AI can address the shortage of skilled teachers by offering virtual tutoring and mentoring programs, as Participant Two stated.* By harnessing the power of AI, South Africa can make significant progress in achieving SDG 4, which aims to ensure inclusive and equitable quality education for all.

Subsequently, Lecturers can identify and address students' learning gaps with AI, providing targeted support and interventions. *Lecturers can also use this technology to streamline administrative tasks, such as student enrolment and progress tracking, so they can devote more time to teaching, as noted by Participant Three.* In addition, AI can facilitate the development of adaptive learning platforms that adapt to students' individual needs and learning styles, creating a more engaging and effective learning environment. Integrating AI into South African education has helped the country bridge the educational divide and ensure all children have access to quality education. *Participant One noted that because of AI, lecturers can provide students with personalized feedback and assessments, help them identify their strengths and weaknesses and adapt their teaching methods as necessary.* This individualized approach can significantly improve student outcomes and overall academic performance. Moreover, AI-powered virtual tutors and learning assistants can provide round-the-clock support to students, enabling them to access educational resources and guidance whenever needed. Incorporating AI in South African education can transform how students learn, and educators teach, resulting in a more fair and inclusive educational system.

4.3. Primary challenges do higher education institutions in South Africa face when implementing AI technologies.

Higher education institutions in South Africa face several challenges when implementing AI technologies. These challenges include technology infrastructural limitations, skills gaps, and budget constraints, among others. Despite these problems, some institutions are trying to overcome them by upgrading their technological infrastructure, providing training programs to bridge skills gaps, and seeking funding opportunities to support AI initiatives.

Theme Three: Pitfalls and solutions of AI technology

The theme focused on the pitfalls and critical solutions in addressing the challenges of AI technology.
The participants agreed that the major difficulties in using AI technology in South Africa are the infrastructural deficit and internet connectivity, particularly in rural areas. This impedes AI technology's widespread acceptance and access, limiting

its potential influence on South Africa's higher education system. In addition, the country (South Africa) suffers from a scarcity of experienced professionals and AI expectations, making creating and deploying AI solutions efficiently cumbersome. *Eish!!! South Africa is a diverse country, raising concerns about the ethical implications of AI algorithms, Participant One affirmed.* These issues must be addressed for AI to be implemented responsibly and inclusively. *Hayibo!!! Loadshedding is almost crippling various sectors in the South African economy, Participant Five highlighted.* Addressing these challenges requires a multifaceted approach. First, the government must invest in improving rural internet connectivity by building and upgrading infrastructure. By doing this, all citizens will benefit from AI technology on an equal footing. *Participant Two observed that efforts should be made to close the skills gap by offering training and educational programs to develop a new generation of AI professionals.* This will aid in the effective development and deployment of AI solutions, as well as the creation of job opportunities and the stimulation of economic growth. Finally, ethical norms and regulations must be implemented to ensure that AI algorithms are objective and do not perpetuate societal imbalances. By following these steps, South Africa can fully realise AI's potential while ensuring its responsible and inclusive application.

Yebo!!! (meaning Yes), The swift improvements in AI technology can make South Africa the leader in these sectors and transform the lives of its citizens, Participant One asserted. By harnessing the power of AI, the country can tackle the challenges it faces in healthcare, agriculture, and transportation, among other problems in South Africa. AI-powered medical tools can provide accurate and timely diagnoses, enabling doctors to deliver better healthcare outcomes. AI algorithms can analyze data from sensors and satellites to optimize crop yields, reduce waste, and increase food production in the agricultural sector. Additionally, AI can improve transportation efficiency by optimising routes, reducing congestion, and promoting renewable energy sources. *Participant Two stated akere… meaning right, by embracing AI and ensuring its responsible and inclusive implementation, South Africa can bridge education and healthcare access gaps in remote areas.* This technology can provide virtual classrooms, telemedicine services, and healthcare monitoring systems, reaching previously underserved people. *Wena… (i.e., you see), AI can play a crucial role in reducing crime rates by analyzing patterns and predicting criminal activities, aiding law enforcement agencies to maintain public safety and peace, Participant One discloses.* Lastly, by promoting equal opportunities and addressing biases in AI algorithms, South Africa can strive towards a future where every citizen has a fair chance to succeed. Through investments in technology and education, South Africa can create a prosperous and equitable society for all.

5. Discussion

The SDGs are significant to South Africa as they address critical societal and environmental challenges, making them a national priority. AI has the potential to play a pivotal role in advancing the SDGs by providing innovative solutions and addressing complex challenges across various sectors, including education. South Africa's higher education system is diverse, with multiple institutions offering varied programs. However, it faces challenges related to access, equity, and quality. The findings of this study reveal that implementing AI technology

will enhance student learning and engagement in South Africa's higher education system, and several studies (George & Wooden, 2023; Pedro et al., 2019) supported this result. South African higher education institutions confront challenges in access, affordability, and disparities (Ramaahlo et al., 2018; Ramrathan, 2018). AI offers opportunities to address these issues, but ethical considerations and the digital divide must be addressed. AI is progressively integrated into South African universities, enhancing teaching, research, and administrative processes. However, a structured approach is essential for maximizing its potential. Wang (2021) study confirmed the result of this study about AI in education, which offers benefits such as personalized learning, improved access, and data-driven decision-making. It can address gaps in the educational system and enhance the learning experience. AI can contribute to advancing various SDGs by addressing societal challenges in healthcare, agriculture, environmental conservation, and education (Fan et al., 2023; Goralski & Tan, 2020). Its potential extends to numerous sectors. Identifying priority SDGs for higher education involves considering South Africa's unique challenges, such as access to quality education, healthcare, and economic development.

The study further revealed that AI contributes to achieving quality education in South Africa. The findings align with the results of Ali et al. (2020), who stated that integrating and applying AI classrooms can make teaching and learning more effective by supporting teachers and learners using robotic technology and sensors. Also, AI technology-based assessment systems can be used to assess students' knowledge, understanding, skills, and characteristics, such as collaboration, persistence, confidence, and motivation (Alam et al., 2022). Likewise, Teachers can use AI to help them with administrative activities like grading and lesson planning, giving them more time to focus on individualized instruction (Kabudi, 2022). AI-driven initiatives are being implemented globally, such as IBM Watson for healthcare and Duolingo for language learning, showcasing the diverse applications of AI. Establishing a comprehensive policy and institutional framework is critical for the responsible integration of AI in South African higher education. This framework should address ethics, capacity building, and resource allocation.

Finally, we found that AI can help law enforcement organizations maintain public safety and peace by analyzing patterns and forecasting criminal behaviors. The result was in tandem with the study of Ezzeddine et al. (2023), who presented that it is crucial to consider societal concerns and integrate propositions of safeguards to ensure responsible and ethical use of AI by law enforcement agencies, particularly in the context of cybercrime and terrorism. Governments play a crucial role in promoting AI in education through policies supporting research, funding, curriculum integration, and ethical guidelines. To successfully adopt AI, higher education institutions must develop strategies for faculty development, encompassing training, collaboration, and resources. Partnerships with industry and research institutions offer access to expertise, resources, and real-world applications of AI, enhancing educational initiatives. The future of AI in South African higher education promises enhanced learning experiences, inclusivity, research advancements, and innovation, along with the need for ethical

considerations and adaptability. AI in education is evolving with trends like personalized learning, intelligent tutoring systems, gamification, and ethical AI. These trends are reshaping the educational landscape.

6. Conclusion

This study uses a qualitative research method to harness AI to advance SDGs in South Africa's higher education system. To this end, the study aimed to determine the AI technologies adopted in South African higher education institutions, ascertain how AI affects SDG advancement in South African education, and identify the primary challenge higher education institutions in South Africa face when implementing AI technologies. AI presents a transformative opportunity to advance SDGs, with particular significance for the education sector. In South Africa, harnessing AI in higher education holds the potential to address disparities, improve access, and enhance the overall quality of education. As we reflect on the importance of AI in South African higher education, we must recognise its pivotal role in achieving SDGs, especially SDG 4, which aims to ensure inclusive and equitable quality education for all.

In addition, harnessing AI to advance the SDGs in South Africa's higher education system presents many opportunities and challenges. The significance of the SDGs in South Africa lies in their potential to address critical societal and environmental issues, and AI can play a pivotal role in achieving these goals. South African higher education institutions are crucial in preparing students for AI-centric careers and contributing to SDG advancement. The integration of AI in South African higher education offers the promise of personalized learning experiences, improved access and inclusivity, research advancements, and enhanced workforce readiness. However, it also brings ethical and privacy considerations that must be addressed responsibly. Collaboration with industry and research institutions can bolster AI initiatives in higher education and drive innovation.

The prospects of AI in South African higher education are promising, with emerging trends and technologies that have the potential to reshape the educational landscape. Research and development areas, such as personalized learning environments, AI ethics, and inclusive AI technologies, are at the forefront of AI innovation in education. In preparing students for AI-centric careers, higher education institutions must provide a holistic education encompassing technical skills, ethical awareness, soft skills, and opportunities for real-world experience. As South Africa continues its journey toward harnessing AI for SDG advancement, it is essential to maintain a commitment to ethical AI use, collaboration, and continuous adaptation to technological advances. By doing so, South African higher education can play a pivotal role in driving innovation, addressing societal challenges, and contributing to a brighter, more sustainable future aligned with the SDGs.

Implication

The implications of harnessing AI for advancing SDGs in South Africa's higher education system are profound. They involve improving education quality, inclusivity, research, and ethics while preparing students for AI-centric careers.

These implications align with various SDGs, making AI integration an essential driver of progress in South African higher education and society. AI make education more accessible to diverse student populations, including those in remote areas or with disabilities. This will help bridge educational disparities and promote inclusivity, aligning with SDG 4 (Quality Education). AI creates personalized learning experiences, improving student engagement and understanding of complex concepts. Enhanced learning experiences contribute to SDG 4 by ensuring quality education and lifelong learning opportunities. Data-driven decision-making through AI can optimize resource allocation within educational institutions. Efficient resource use aligns with SDG 9 (Industry, Innovation, and Infrastructure) by fostering infrastructure development and technological advancement.

Efforts to bridge the digital divide can provide underprivileged communities access to AI-driven education. Bridging the digital divide contributes to SDG 10 (Reduced Inequalities) by reducing disparities in access to information and communication technologies. AI supports scientific research and innovation in various fields, which can address societal challenges. This aligns with SDG 9 by fostering research, innovation, and infrastructure development. Harnessing AI's transformative potential empowers higher education to address societal challenges actively. The transformative potential contributes to multiple SDGs by improving education, reducing inequalities, and fostering innovation. To ensure that AI adoption in South African higher education is aligned with SDGs and benefits all stakeholders, it is crucial to develop practical recommendations and guidelines for policymakers, educators, and institutions. By addressing this research problem, it will be possible to understand how AI can be effectively harnessed to drive sustainable development in South Africa's higher education system. The research should not only focus on the technological aspects but also encompass the social, ethical, and economic dimensions of AI integration, ensuring that the goals of equity, quality education, and lifelong learning are met and consistent with the principles of sustainable development.

Recommendations for Policymakers:
Developing clear policies and regulations are essential to guide the responsible use of AI in South African higher education. These policies should foster innovation while protecting students' rights, ensuring fairness, and promoting ethical AI use. Here are some key aspects to consider in this context. The South African government should formulate a comprehensive national AI education policy that outlines the objectives, principles, and guidelines for integrating AI into higher education. This policy should provide a framework for promoting AI-driven initiatives, establishing standards for AI implementation, and allocating resources. Policymakers should engage with universities, educators, students, industry representatives, and AI experts to create policies that align with the needs and aspirations of the South African higher education sector. In addition, AI policies should be dynamic and capable of adapting to the rapid evolution of AI technologies. Regular reviews and updates should be built into the policy framework to keep it current and relevant.

Furthermore, in infrastructural development, the government should invest in digital infrastructure. Efforts to bridge the digital divide are critical for ensuring that AI technologies can be effectively integrated into South African higher education. These measures will help create an equitable and supportive environment for AI adoption in education. However, the South African government should prioritise expanding broadband internet access, particularly in underserved and rural areas. Reliable and high-speed internet connectivity is essential for effective online and AI-driven education. Also, as a matter of urgency, the South African government should address the problem of loadshedding and invest in reliable power infrastructure, particularly in areas with frequent power outages.

Finally, practical training for educators and students is vital to successfully integrating AI technologies into South African higher education. This training ensures that teachers and students can leverage AI for improved learning outcomes, are prepared for an AI-driven future, and develop programs that provide teachers with the skills and knowledge to effectively integrate AI-powered tools and platforms into their teaching methods. These programs can encompass AI basics, pedagogical strategies, and best practices. Also, educational institutions should provide ongoing support for educators, including workshops, mentoring, and access to AI experts who can offer guidance and assistance.

7. Limitation of the study

The study on harnessing AI for advancing SDGs in South Africa's education system: a qualitative study bears some notable limitations. Firstly, its findings may not be broadly generalizable due to its focus on the specific context of South Africa's higher education landscape. To this effect, more studies need to be conducted to incorporate other education institutions to have a holistic view of this topic. Subsequently, the sample size and scope may restrict the applicability of its insights beyond this study. To improve the robustness of findings, the sample size can be increased to draw a convincing conclusion that can be applied to a broader range of educational institutions. In addition, the qualitative nature of the research may also be limited by potential biases in data collection and analysis, as well as the subjective interpretation of the researchers. To address these limitations, future research could consider using a mixed-method approach to provide a more comprehensive understanding of the study. Overall, while the study offers valuable insights into AI for advancing SDGs for South Africa's education system, it is essential to recognize and address its limitations to ensure the validity and reliability of its findings.

8. References

Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, 2(3), 431-440. https://doi.org/10.1007/s43681-021-00096-7

Alam, A. (2023). Harnessing the Power of AI to Create Intelligent Tutoring Systems for Enhanced Classroom Experience and Improved Learning Outcomes. In G. Rajakumar, K.-L. Du, & Á. Rocha, *Intelligent Communication Technologies and Virtual Mobile Networks* Singapore.

Alam, A., & Alam, S. (2021). Evolution of Artificial Intelligence in Revolutionising Web-Based and Online Intelligent Educational Systems. *SPAST Abstracts*, 1(01). https://spast.org/techrep/article/view/506).

Alam, A., Hasan, M., & Raza, M. M. (2022). Impact of artificial intelligence (ai) on education: changing paradigms and approaches. *Towards Excellence*, 14(1), 281-289. https://doi.org/10.37867/te140127

Ali, M. Y., Naeem, S. B., & Bhatti, R. (2020). Artificial intelligence tools and perspectives of university librarians: An overview. *Business Information Review*, 37(3), 116-124. https://doi.org/10.1177/0266382120952016

Baker, R. S., & Hawn, A. (2022). Algorithmic Bias in Education. *International Journal of Artificial Intelligence in Education*, 32(4), 1052-1092. https://doi.org/10.1007/s40593-021-00285-9

Boluk, K. A., Cavaliere, C. T., & Higgins-Desbiolles, F. (2019). A critical framework for interrogating the United Nations Sustainable Development Goals 2030 Agenda in tourism. *Journal of Sustainable Tourism*, 27(7), 847-864. https://doi.org/10.1080/09669582.2019.1619748

Bozkurt, A., Karadeniz, A., Baneres, D., Guerrero-Roldán, A. E., & Rodríguez, M. E. (2021). Artificial Intelligence and Reflections from Educational Landscape: A Review of AI Studies in Half a Century. *Sustainability*, 13(2), 800. https://www.mdpi.com/2071-1050/13/2/800

Brand, D. (2022). Responsible Artificial Intelligence in Government: Development of a Legal Framework for South Africa. *JeDEM - eJournal of eDemocracy and Open Government*, 14(1), 130-150. https://doi.org/10.29379/jedem.v14i1.678

Butcher, N., Wilson-Strydom, M., & Baijnath, M. (2021). Artificial intelligence capacity in sub-Saharan Africa: Compendium report.

Carman, M., & Rosman, B. (2023). Applying a Principle of Explicability to AI Research in Africa: Should We Do It? In A. D. Attoe, S. S. Temitope, V. Nweke, J. Umezurike, & J. O. Chimakonam (Eds.), *Conversations on African Philosophy of Mind, Consciousness and Artificial Intelligence* (pp. 183-201). Springer International Publishing. https://doi.org/10.1007/978-3-031-36163-0_13

Carpentier, C. L., & Braun, H. (2020). Agenda 2030 for Sustainable Development: A powerful global framework. *Journal of the International Council for Small Business*, 1(1), 14-23. https://doi.org/10.1080/26437015.2020.1714356

Chakroun, B., Miao, F., Mendes, V., Domiter, A., Fan, H., Kharkova, I., . . . Issroff, K. (2019). Artificial intelligence for sustainable development: synthesis report, mobile learning week 2019.

De Villiers, C., Kuruppu, S., & Dissanayake, D. (2021). A (new) role for business – Promoting the United Nations' Sustainable Development Goals through the internet-of-things and blockchain technology. *Journal of Business Research*, 131, 598-609. https://doi.org/10.1016/j.jbusres.2020.11.066

Ezzeddine, Y., Bayerl, P. S., & Gibson, H. (2023). Citizen Perspectives on Necessary Safeguards to the Use of AI by Law Enforcement Agencies. *arXiv preprint arXiv:2306.01786*.

Fan, Z., Yan, Z., & Wen, S. (2023). Deep Learning and Artificial Intelligence in Sustainability: A Review of SDGs, Renewable Energy, and Environmental Health. *Sustainability*, *15*(18), 13493. https://www.mdpi.com/2071-1050/15/18/13493

George, B., & Wooden, O. (2023). Managing the Strategic Transformation of Higher Education through Artificial Intelligence. *Administrative Sciences*, *13*(9), 196. https://www.mdpi.com/2076-3387/13/9/196

González-Calatayud, V., Prendes-Espinosa, P., & Roig-Vila, R. (2021). Artificial Intelligence for Student Assessment: A Systematic Review. *Applied Sciences*, *11*(12), 5467. https://www.mdpi.com/2076-3417/11/12/5467

Goralski, M. A., & Tan, T. K. (2020). Artificial intelligence and sustainable development. *The International Journal of Management Education*, *18*(1), 100330. https://doi.org/10.1016/j.ijme.2019.100330

Gupta, S., Campos Zeballos, J., del Río Castro, G., Tomičić, A., Andrés Morales, S., Mahfouz, M., . . . Inyaregh, M. (2023). Operationalizing Digitainability: Encouraging Mindfulness to Harness the Power of Digitalization for Sustainable Development. *Sustainability*, *15*(8), 6844. https://www.mdpi.com/20711050/15/8/6844

Gwagwa, A., Kachidza, P., Siminyu, K., & Smith, M. (2021). Responsible artificial intelligence in Sub-Saharan Africa: landscape and general state of play.

Halkos, G., & Gkampoura, E.-C. (2021). Where do we stand on the 17 Sustainable Development Goals? An overview on progress. *Economic Analysis and Policy*, *70*, 94-122. https://doi.org/10.1016/j.eap.2021.02.001

How, M.-L., Cheah, S.-M., Chan, Y. J., Khor, A. C., & Say, E. M. P. (2023). Artificial Intelligence for Advancing Sustainable Development Goals (SDGs): An Inclusive Democratized Low-Code Approach. In F. Mazzi & L. Floridi (Eds.), *The Ethics of Artificial Intelligence for the Sustainable Development Goals* (pp. 145-165). Springer International Publishing. https://doi.org/10.1007/978-3-031-21147-8_9

Kabudi, T. M. (2022). Artificial Intelligence for Quality Education: Successes and Challenges for AI in Meeting SDG4. In Y. Zheng, P. Abbott, & J. A. Robles-Flores, *Freedom and Social Inclusion in a Connected World* Cham.

Kim, S., & Shin, S. (2021). Theoretical Frameworks on Tertiary Education Inequality in the SDG Era. In *Reduced Inequalities* (pp. 842-853). Springer.

Kuleto, V., Ilić, M., Dumangiu, M., Ranković, M., Martins, O. M. D., Păun, D., & Mihoreanu, L. (2021). Exploring Opportunities and Challenges of Artificial Intelligence and Machine Learning in Higher Education Institutions. *Sustainability*, *13*(18), 10424. https://www.mdpi.com/2071-1050/13/18/10424

Makala, B., Schmitt, M., & Caballero, A. (2021). How Artificial Intelligence Can Help Advance Post-Secondary Learning in Emerging Markets.

Mbiza, M., & Sinha, S. (2023). The Fourth Industrial Revolution: Conceptual paradox or catalyst for achieving the Sustainable Development Goals? *South African Journal of Science*, *119*(7/8). https://doi.org/10.17159/sajs.2023/16090

McKeever, M. (2017). Educational Inequality in Apartheid South Africa. *American Behavioral Scientist*, *61*(1), 114-131. https://doi.org/10.1177/0002764216682988

Mhlanga, D. (2021a). Artificial Intelligence in the Industry 4.0, and Its Impact on Poverty, Innovation, Infrastructure Development, and the Sustainable Development Goals: Lessons from Emerging Economies? *Sustainability*, *13*(11), 5788. https://www.mdpi.com/2071-1050/13/11/5788

Mhlanga, D. (2021b). The Fourth Industrial Revolution and COVID-19 Pandemic in South Africa: The Opportunities and Challenges of Introducing Blended Learning in Education. *Journal of African Education*, *2*(2), 15-42. https://doi.org/10.31920/2633-2930/2021/v2n2a1

Mohajan, D., & Mohajan, H. K. (2022). Constructivist Grounded Theory: A New Research Approach in Social Science. *Research and Advances in Education*, *1*(4), 8-16. https://doi.org/10.56397/RAE.2022.10.02

Mzangwa, S. T. (2019). The effects of higher education policy on transformation in post-apartheid South Africa. *Cogent Education*, *6*(1), 1592737. https://doi.org/10.1080/2331186X.2019.1592737

Nkosi, T. L. (2019). *Harnessing the Fourth Industrial Revolution for improved educational infrastructure in South African Higher Education Institutions* University of Johannesburg].

Okewu, E., Adewole, P., Misra, S., Maskeliunas, R., & Damasevicius, R. (2021). Artificial Neural Networks for Educational Data Mining in Higher Education: A Systematic Literature Review. *Applied Artificial Intelligence*, *35*(13), 983-1021. https://doi.org/10.1080/08839514.2021.1922847

Opesemowo, O. A. G. (2023). Development and Validation of a Scale to Measure Quality Education in Oyo State Secondary School. *Journal of Higher Education Theory and Practice*, *23*(17), 59-73. https://doi.org/10.33423/jhetp.v23i17.6534

Opesemowo, O. A. G., & Ndlovu, M. (2023). Status and experience of mathematics teachers' perception of integrating computer adaptive testing into unified tertiary matriculation examination mathematics. *Multicultural Education*, *09*(02), 66-78.

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). Artificial intelligence in education: Challenges and opportunities for sustainable development.

Perumal, R. I. (2010). *The development of universities of technology in the higher education landscape in South Africa*

Pinheiro, R., Ouma, G. W., & Pillay, P. (2012). The Dynamics of University Transformation: A Case Study in the Eastern Cape Province of South Africa. *Journal of Higher Education in Africa / Revue de l'enseignement supérieur en Afrique*, *10*(1), 95-120. http://www.jstor.org/stable/jhigheducafri.10.1.95

Ramaahlo, M., Tönsing, K. M., & Bornman, J. (2018). Inclusive education policy provision in South African research universities. *Disability & Society*, *33*(3), 349-373. https://doi.org/10.1080/09687599.2018.1423954

Ramrathan, S. (2018). *Exploring inequality in institutional marketing: access to higher education by marginalised communities.* (Unpublished doctoral dissertation]. Durban University of Technology.

Saeidnia, H. R. (2023). Ethical artificial intelligence (AI): confronting bias and discrimination in the library and information industry. *Library Hi Tech News*. https://doi.org/10.1108/LHTN-10-2023-0182

Schwartzman, S. (2015). Demands and Policies for Higher Education. In S. Schwartzman, R. Pinheiro, & P. Pillay (Eds.), *Higher Education in the BRICS Countries: Investigating the Pact between Higher Education and Society* (pp. 13-41). Springer Netherlands. https://doi.org/10.1007/978-94-017-9570-8_2

Shiohira, K. (2021). Understanding the Impact of Artificial Intelligence on Skills Development. Education 2030. *UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training*.

Sivanath, A. (2020). *Teaching and learning challenges of disadvantaged students in the context of access and equity in South African higher education: a case study of the Durban University of Technology*

Sutherland, E. (2020). The Fourth Industrial Revolution – The Case of South Africa. *Politikon*, *47*(2), 233-252. https://doi.org/10.1080/02589346.2019.1696003

Tsalis, T. A., Malamateniou, K. E., Koulouriotis, D., & Nikolaou, I. E. (2020). New challenges for corporate sustainability reporting: United Nations' 2030 Agenda for sustainable development and the sustainable development goals. *Corporate Social*

Responsibility and Environmental Management, *27*(4), 1617-1629. https://doi.org/https://doi.org/10.1002/csr.1910

Vincent, B. C., Mgaya, O. P., & Kamamia, J. W. (2023). Analysing the Limitations of African Institutions of higher Education in Enhancing Creativity, Research and Innovation in Agriculture for Food Security as a Sustainable Development Goal.

Vittorini, P., Menini, S., & Tonelli, S. (2021). An AI-Based System for Formative and Summative Assessment in Data Science Courses. *International Journal of Artificial Intelligence in Education*, *31*(2), 159-185. https://doi.org/10.1007/s40593-020-00230-2

Wakunuma, K., Ogoh, G., Eke, D. O., & Akintoye, S. (2022, 16-20 May 2022). Responsible AI, SDGs, and AI Governance in Africa. 2022 IST-Africa Conference (IST-Africa),

Wang, Y. (2021). When artificial intelligence meets educational leaders' data-informed decision-making: A cautionary tale. *Studies in Educational Evaluation*, *69*, 100872. https://doi.org/10.1016/j.stueduc.2020.100872

Zeleza, P. T., & Okanda, P. M. (2021). Enhancing the Digital Transformation of African Universities Covid-19 as Accelerator. *Journal of Higher Education in Africa / Revue de l'enseignement supérieur en Afrique*, *19*(1), 1-28. https://www.jstor.org/stable/48645900

Zhou, C., & Etzkowitz, H. (2021). Triple Helix Twins: A Framework for Achieving Innovation and UN Sustainable Development Goals. *Sustainability*, *13*(12), 6535. https://www.mdpi.com/2071-1050/13/12/6535