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RESEARCH ARTICLE

Artificial Intelligence Technologies Integration and Global Competitiveness in Higher Education: Evidence from Sub-Saharan Africa

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ABSTRACT

Sustainable learning outcomes are vital for developing strong critical thinking skills, which lead to positive life results and career success, ultimately enhancing global competitiveness. Achieving these outcomes relies on instructional methods that offer meaningful experiences to learners. This study explores the use of Artificial Intelligence (AI) technologies as learning strategies to boost the global competitiveness of higher education institutions and students in Sub-Saharan Africa. The research aimed to evaluate how AI impacts sustainable learning outcomes and to identify challenges that hinder their implementation in higher education, based on evidence from the region. A mixed-method research design was adopted, with stratified and simple random sampling techniques used to determine the sample size. The population of respondents was 3840 with the sample size of 384 that included students and an academic staff. Data collection involved questionnaires named Artificial Intelligence Technologies Integration Questionnaires (AITIQ) and Global Competitiveness in Higher Education (GCIEQ) with Artificial Intelligence Technologies Integration interview guides (AITII) and Global Competitiveness in Higher Education Interview guides (GCHEI). Quantitative responses analyzed using SPSS Version 27 because it is easy accessible for researcher. That generated descriptive statistics and reliability calculated while qualitative data from interview guides were subjected to thematic and narrative analysis. The results show that 355(92.45%) with mean of 4.35 of students agreed that, integrating AI technologies can greatly improve sustainable learning outcomes by increasing administrative efficiency, enabling personalized learning, automating assessments and feedback, and enhancing global competitiveness. However, super majority of students above 75% agreed that, at study area there are challenges such as limited technical expertise and infrastructure, low digital literacy among staff, and concerns that AI can decrease critical thinking among students. The study concludes that the successful integration of AI in higher education, need to be guided by strategic policies, can transform learning practices and improve academic results. It recommends investing in AI infrastructure, offering regular staff training, and continuously evaluating AI tools to ensure fairness and effectiveness.

Keywords: Artificial Intelligence, Integration, Learning Strategies, Global Competitiveness

INTRODUCTION

The fast pace of AI development has made significant changes in the field of higher education, altering the way universities deliver instruction, assess learners'

performance, support students, carry out scientific research, and administer various processes within the university system. According to the definition of UNESCO (2021) and OECD (2025), AI includes

computer-based systems that are able to execute a set of tasks which usually requires human intelligence, such as analysis of data, pattern recognition, natural language processing, response generation, recommendation, and decision-making. Therefore, in the context of higher education, AI stands out from ICT by the fact that it does not only imply the presence of digital infrastructure or communication technologies, but it also includes computational systems that are capable of analysis, learning from patterns, response generation, automatization of decision-making, and other processes. Relevant examples of technologies include machine learning, natural language processing, intelligent tutoring systems, adaptive learning platforms, automated assessment, AI-based feedback, predictive analytics, chatbots, and generative AI applications (Zawacki-Richter et al., 2019). The increased use of AI in higher education allows universities to raise their competitiveness in the knowledge-intensive global economy (Holmes et al., 2022).

The rise of AI in higher education takes place in an extremely uneven technological environment worldwide. Universities in developed countries normally function in a stronger digital infrastructure, higher research and development capacities, better connectivity with the help of high-speed Internet, and already developed institutional structures facilitating the integration of innovative technologies into the educational process (Holmes et al., 2022). Thus, according to the reports by the Organization for Economic Co-operation and Development, there was a noticeable difference in the implementation of AI in education systems; in 2024, up to 75% of teachers in Singapore and the United Arab Emirates reported AI use (OECD, 2025), thus showing a relatively developed institutional environment for AI-supported education in some of the digitalized systems. At the institutional level, a UNESCO survey conducted in 2025 revealed that out of 400 respondents from UNESCO Chairs and UNITWIN networks in 90 countries nine out of ten people used AI tools in their professional activity, whereas almost half of the participants tried AI in educational practice, including planning of lessons, grading, and plagiarism checking. However, uneven confidence in effective usage of AI in pedagogical and research practice was observed (UNESCO, 2025). This evidence shows that discussions in developed and technologically advanced education systems increasingly become

focused on how to implement AI rather than whether to use it or not (UNESCO, 2021; OECD, 2025).

In the case of many developing nations, especially Sub-Saharan African countries, the implementation of AI is limited due to a variety of infrastructural, monetary, technical and human capacity limitations. According to the data provided by the World Bank, the internet penetration in Sub-Saharan Africa was around 36% in 2025, which is much lower than in many developed countries (World Bank, 2026). Yet, the region has made impressive progress in its digitalization process. From 2019 to 2022, 160 million extra people living in the region have been provided with broadband internet which shows the fast-paced development of the region's digital infrastructure. Despite the progress achieved, there are still numerous disparities in the sphere, such as access, cost, quality, and use of internet services. Thus, in 2021, 84% of the region's population lived in zones covered by 3G networks, 63% had 4G coverage available, yet only 22% used mobile internet. It is important for higher education purposes as the efficient implementation of AI-based learning is impossible without internet access, appropriate technological equipment, electricity, digital skills and affordable access to the internet services (Zawacki-Richter et al., 2019).

Within this context, higher education institutions in Sub-Saharan Africa are increasingly expected to use emerging technologies to address persistent educational challenges while simultaneously preparing graduates for an increasingly competitive global labour market. Universities in the region serve rapidly expanding student populations but often operate with comparatively constrained financial resources, inadequate digital infrastructure, large student-to-staff ratios, limited access to advanced educational technologies, and uneven digital competencies among academic and administrative staff (UNESCO, 2021). Consequently, AI may provide an opportunity to increase institutional capacity through automated administrative processes, intelligent student-support systems, personalised learning, automated assessment, data-informed decision-making, and early identification of students who may require additional academic assistance (Zawacki-Richter et al., 2019; Holmes et al., 2022). However, these opportunities cannot automatically be transferred from developed-country contexts to African universities because differences in infrastructure, institutional capacity, pedagogical

practices, language, affordability, digital literacy, and regulatory environments may affect how AI is adopted and its eventual educational impact (Holmes et al., 2022).

Global competitiveness in higher education plays a key role as one of the contexts in the understanding of the importance of AI adoption. Global competitiveness is defined as the ability of institutions and their graduates to compete internationally and operate effectively within the globalized world through good teaching practices, research productivity, innovation, employability, internationalization, knowledge production, and adaptation to technological and social changes (Marginson, 2022). As pointed out by Marginson (2022), today, higher education operates in conditions of influence of global knowledge systems, international competition, research visibility, mobility, and knowledge production. For Sub-Saharan African universities, the idea of competitiveness plays an important role as institutions have to deal at once with national development needs and international standards of teaching, research, innovation, and graduate employability. AI can help achieve that through the increased efficiency of academic services, the enhancement of research and knowledge production, increased opportunities for personalized learning, improvement of assessment and feedback processes, and participation of universities in global digital knowledge networks (Holmes et al., 2022).

Sustainable learning outcomes constitute another important dimension of the present study. Sustainable learning outcomes refer to knowledge, skills, competencies, attitudes, and problem-solving abilities that learners acquire and retain over time and can transfer to new academic, professional, and social situations (UNESCO, 2021). Rather than focusing only on short-term examination performance, sustainable learning emphasizes deeper understanding, critical thinking, creativity, collaboration, adaptability, and the ability to continue learning beyond the formal classroom. UNESCO (2021) emphasizes the importance of educational approaches that prepare learners for changing social, technological, and economic environments. AI has the potential to support such outcomes through personalised learning pathways, immediate feedback, adaptive learning resources, intelligent tutoring, automated identification of learning difficulties, and access to diverse sources of knowledge (Holmes et al., 2022; Zawacki-Richter et

al., 2019). Nevertheless, excessive dependence on AI may also create risks, including reduced independent thinking, academic dishonesty, inaccurate information, privacy concerns, and diminished learner autonomy (UNESCO, 2021; UNESCO, 2023). Thus, the educational value of AI depends not simply on its availability but on the manner in which universities, lecturers, and students integrate it into the learning process.

It becomes critical within the African context because of the limited empirical studies that exist concerning the implementation of AI in higher education. A considerable part of early research on AI-enabled higher education has been produced in North America, Europe, and Asia, where universities enjoy comparatively better digital infrastructure, higher financing, access to specialists in certain spheres, and a longer history of using educational technology (Zawacki-Richter et al., 2019). The evidence from Sub-Saharan Africa is required since the effectiveness of the implementation of AI cannot be assumed to be similar in all situations. The existing issues in Africa are related to poor infrastructure, lack of electricity and internet connection, lack of skills regarding the use of AI in lecturers and students, cost-effectiveness of digital products, lack of institutional policy, ethics issues, and students' dependence on AI-generated information (Ndukwe & Daniel, 2020; Adeoye & Jimoh, 2022; UNESCO, 2021). It can be said that these problems match those mentioned in the wider context in which Sub-Saharan Africa still suffers from significant digital and skills gaps (World Bank, 2024).

Institutional preparedness for AI adoption is also an important contextual issue. UNESCO's 2023 global survey of more than 450 schools and universities found that fewer than 10% had developed formal policies or guidance on generative AI, while only approximately 13% of universities reported having some form of guidance (UNESCO, 2023). Although the situation has progressed considerably, the evidence illustrates how quickly AI has developed relative to institutional policy and governance mechanisms. A more recent UNESCO survey found that 19% of participating higher education institutions had a formal AI policy, while a further 42% were developing AI-related guidance. Importantly, institutions in Europe and North America were more likely to have or be developing guidance than institutions in other regions (UNESCO, 2025). This comparison suggests that AI adoption should be

examined not merely as a technological issue but as an institutional, pedagogical, managerial, and policy issue.

This study therefore takes place within the context of higher education institutions in Sub-Saharan Africa, where there is pressure on the universities to enhance the quality of education, respond to technological changes, educate competent graduates, and compete in international knowledge systems while facing relatively more constrained technological and institutional contexts. In this case, the study focuses specifically on AI technology as an educational and institutional strategy, and not ICT generally. The concept of AI technology can be defined using four dimensions. These dimensions include: administrative efficiency, personalized learning, automated assessment and feedback, and improvement of global competitiveness. Administrative efficiency refers to the automation of academic and administrative processes, information processing, students' services, and decision-making processes using AI. Personalized learning refers to adaptation of the learning content, process, resources, and support using AI to suit the learners. Automated assessment and feedback refers to the process of marking, evaluation of learning, gap identification, and feedback to learners. Improvement of global competitiveness refers to the extent to which AI-enabled practices at the university enhance the educational process in terms of quality, innovations, research capacity, preparation of graduates, and internationalization of the university (Zawacki-Richter et al., 2019; Holmes et al., 2022).

The research is underpinned by the Technology Acceptance Model and Connectivism. TAM can help in the investigation as the successful use of AI in universities partly depends on the perception by lecturers, students and institutional users of AI technologies as being useful and easy to use and hence acceptance and use of AI technologies in education (Davis, 1989). The model will thus be able to account for the factors determining the adoption and use of AI in universities. Connectivism can be used together with the TAM in explaining learning in technology rich environments characterized by a distribution of knowledge in individuals, digital media, networks, databases and technological systems (Siemens, 2005). Learning in an AI-supported university will largely depend on the capacity to locate useful information, create connections among sources of information, critically analyze information

and knowledge created through technology and updating of knowledge and skills on a continuous basis.

Therefore, the research does not presume that the presence of AI alone will result in better education results and global competitiveness. On the contrary, the research investigates how certain applications of AI are related to sustainable learning outcomes and global competitiveness in terms of the contextual realities of higher education in Sub-Saharan Africa. It is believed that the findings of the research will bring about some empirical data that will help university leadership, policy-makers, lecturers, and other interested parties figure out how AI can be utilized responsibly. Such findings can also contribute to policies, infrastructure development, teacher training, AI literacy programmes, examination systems reform, ethical guidelines, and university international competitiveness enhancement strategies. In terms of studying AI specifically and not ICT as a whole, and making the comparison between developed and developing country technologies, the research is aimed at providing some contextually relevant data in the increasingly heated discussion of the role of AI in sustainable learning outcomes and global competitiveness in higher education.

Objective of the Study

This study is guided by the following specific objectives:

1. To evaluate the impact of AI technologies on sustainable learning outcomes in higher education institutions in Sub-Saharan Africa.
2. To identify challenges that hinders the effective implementation of AI technologies in higher education in Sub-Saharan Africa

LITERATURE REVIEW

Theoretical Framework

These include Connectivism as suggested by Siemens (2005) and TAM as suggested by Davis (1989) and then adapted into the educational sphere by Venkatesh and Bala (2008). Under Connectivism theory, Siemens argues that learning in the age of technology consists of establishing connections between nodes of information on networks that might be physical, organizational and/or technological in nature and that the ability to manage the connections among different information sources constitutes a crucial capability of modern learners. As far as AI applications in education are concerned,

Connectivism provides a basis for understanding how AI systems, which are likely to serve as intelligent nodes in the information network of the learner, can increase the ability of the learner to establish connections through a more profound, extensive and efficient utilization of information resources and thus contribute to sustainable learning and competitive advantage, which are the objectives of this research. While the TAM theory and its extensions in the realm of education create an additional theoretical foundation via their discussion of the factors that facilitate acceptance, adoption, and efficient use of AI technologies by university staff and learners, Connectivism assists in understanding how the same technologies can be introduced into the university context in order to foster sustainable learning outcomes. The core of the Technology Acceptance Model is the notion that there are two crucial predictors of user acceptance, namely perceived usefulness and ease of use. Meanwhile, the presence of institutional support, training and solid infrastructure serves as a good foundation for the perceptions of usefulness and ease of use. If applied to the context of Sub-Saharan Africa, TAM would help to understand the problems associated with introduction of AI technologies at Sub-Saharan African universities, such as poor digital literacy of personnel and weak infrastructure due to low perceptions of usefulness and lack of institutional support, respectively.

Empirical Literature Review

At the global level, Zawacki-Richter et al. (2019) conducted a systematic review of 146 studies on AI applications in higher education published between 2007 and 2018, finding that the most prevalent AI applications were adaptive learning systems, learning analytics, and intelligent tutoring systems, all of which were associated with significant improvements in student engagement, learning efficiency, and academic performance. The review found that AI-powered personalized learning interventions, in particular, demonstrated the most consistent positive effects on sustainable learning outcomes, as they enabled students to learn at their own pace and receive immediate, targeted feedback that reinforced understanding and corrected misconceptions. These global findings are directly relevant to the current study, as they establish the empirical foundation for the claim that AI integration can meaningfully improve learning outcomes in

higher education, a claim that the current study examines in the specific context of Sub-Saharan Africa. This implies that personalized learning ought to be seen as a significant dimension of AI technology in the context of sustainable learning outcomes. But since the studies that have been analyzed were carried out mainly outside Sub-Saharan Africa, there is need for the current study to ascertain if such advantages can be attained in the Sub-Saharan African university setting.

Holmes et al. (2022) examined the ethical dimensions of AI in education and found that while AI technologies offer significant potential for improving learning outcomes and institutional efficiency, their deployment raises important concerns about data privacy, algorithmic bias, and the erosion of the human dimensions of teaching and learning. The study recommended that AI integration in higher education be guided by clear ethical frameworks that prioritize learner agency, critical thinking development, and equitable access, recommendations that are particularly pertinent for Sub-Saharan African universities, where inequitable access to technology and digital literacy gaps could amplify rather than reduce existing educational inequalities if AI deployment is not carefully managed. It is clear from this that in evaluating the impact of AI in the present context, the focus should be both on technological feasibility and enhanced learning outcomes, but also in respect to the organizational context in which the implementation of AI occurs. This provides a justification for looking at the impact of AI in respect to responsible AI usage, personnel capabilities, and organizational readiness in the present research context.

In South Africa, Ng'ambi et al. (2020) studied the trajectory of technology-enhanced teaching and learning across South African higher education institutions over two decades and found that while technology integration had substantially improved instructional quality and student access in some institutions, the benefits remained unevenly distributed across institutional types, with historically disadvantaged universities consistently lagging in both technology infrastructure and staff capacity for technology-enhanced pedagogy. A study by Spaul (2019) further documented that the benefits of educational technology in South Africa were most strongly felt in institutions with adequate infrastructure and trained staff, a finding that directly informs the current study's emphasis on

infrastructure investment and staff development as prerequisites for effective AI integration in Sub-Saharan African universities. This implies that the success of the role of AI in sustainable learning and competitiveness may rely very much on the presence of infrastructural resources and capable teaching faculties. This means that the current study must take into consideration the use of AI under the prevailing circumstances at Sub-Saharan African universities, and not just assume that simply using the technology will lead to positive results. The evidence from South Africa is a starting point for analyzing if there is a relationship between institutional strength and AI-based educational activities.

In Rwanda, Uwamariya and Musengimana (2021) investigated the adoption of digital learning technologies in Rwandan universities in the context of the government's ambitious digital transformation agenda and found that while government investment in digital infrastructure had substantially improved technology access, the corresponding capacity building for academic staff remained insufficient. The study found that academic staff with higher levels of digital literacy demonstrated significantly more effective use of technology in teaching, generating better student learning outcomes and stronger student engagement. This finding is directly reflected in the current study's identification of low digital literacy among staff as a primary challenge to AI integration in Sub-Saharan African universities, and reinforces the study's recommendation for sustained, institution-wide staff training in AI literacy and pedagogical application. The implication of this on the current study is that the level of staff digital competency must be considered as one of the key conditions for converting the availability of AI to learning results. As suggested by the Rwandan study, simply putting money into building the technology might not be enough; hence, the current study should consider the role of AI utilization, digital competence, and sustainable learning outcomes. This further means that universities wishing to enhance global competitiveness through the use of AI must put money into both technology and professional training. In Kenya, Mugo and Muthee (2021) examined the integration of e-learning technologies in public universities and found that while awareness of digital learning tools was growing among both academic staff and students, actual integration into teaching and learning practices remained superficial due to inadequate infrastructure, unreliable internet

connectivity, and limited institutional support for technology adoption. The study concluded that sustainable improvement in learning outcomes through technology integration required parallel investment in infrastructure, staff capacity, and institutional policy, rather than technology adoption alone. These findings are particularly relevant to the Sub-Saharan African context of the current study, as they demonstrate that technology integration without corresponding investment in human and institutional capacity produces only surface-level change that fails to deliver the learning outcome improvements that AI technologies are theoretically capable of generating. The implication for the present research is that AI usage should be studied within the context of institutions and not simply in terms of technology access. This result is consistent with the present study's investigation of administrative efficiency, personalized learning, automated testing and feedback, and global competitiveness since their effective implementation would need adequate infrastructure, institutional support, personnel capacity, and supportive policies. Thus, the present findings from Kenya serve as a foundation to examine whether such factors are equally relevant in other Sub-Saharan African universities.

Ndukwe and Daniel (2020) conducted a pioneering study on AI readiness and academic staff capacity in Nigerian universities, finding that while awareness of AI among academic staff was growing rapidly, practical competency levels in AI-assisted pedagogy, research applications, and student support remained very low. The study identified the absence of institutional AI policies, inadequate ICT infrastructure, and limited staff training as the primary barriers to meaningful AI integration. Adeoye and Jimoh (2022) further found that Nigerian university staff who had received structured digital skills training demonstrated significantly higher levels of technology-integrated instructional quality, suggesting that staff development is the most critical investment for improving AI integration outcomes. These findings from West Africa are directly relevant to the current study, as they identify structural challenges, particularly staff capacity and institutional policy, that are characteristic of the Sub-Saharan African higher education landscape more broadly. For the ongoing research, the significance of this finding is that AI preparedness, policy, and staff training are some of the key determinants in assessing the role of AI in sustainable learning and competitiveness. From

the Nigerian context, it is evident that universities will not benefit from the application of AI by just possessing AI tools but also by ensuring there is capacity in terms of human resource and institutions for leveraging these tools. The ongoing research is therefore expected to offer empirical evidence on whether applications of AI have made any difference. In Tanzania, the primary geographic context of this study, Mkude and Cooksey (2022) documented the state of ICT integration in Tanzanian universities and found significant disparities in AI readiness between urban and rural institutions, with institutions in Dar es Salaam and Arusha demonstrating substantially higher levels of digital infrastructure and staff AI literacy compared to regional universities. The study noted that Tanzanian universities with higher AI readiness levels reported better student retention rates, stronger research outputs, and more favorable graduate employment outcomes, findings that support the current study's thesis that AI integration is positively associated with global competitiveness indicators in Sub-Saharan African higher education. The implication for the current study is crucial given that the evidence from Tanzania shows that there are differences in terms of technological readiness depending on the context within the same national higher education system. This means that the evidence from the highly developed universities located in cities does not necessarily reflect the reality at regional universities. The current study is thus crucial for providing evidence specific to the context about how the use of AI technology enhances sustainable learning outcomes and global competitiveness under the prevailing circumstances in the chosen higher education institution in Tanzania. General implications from the empirical literature review: It is important to note that the above-mentioned empirical studies provide evidence that AI technologies can be used as effective tools that help improve students' performance, engagement, the efficiency of higher education institutions and their competitiveness. Yet at the same time, it becomes clear that the use of such technologies requires several conditions to be met – these include sufficient infrastructure and connectivity, competence of the institution personnel, institution's policy on technology usage and ethics, financing possibilities, etc. First of all, it should be emphasized that most of the evidence provided by the studies comes from either developed countries or general technology-enhanced learning contexts, not from the empirical

research on AI in Sub-Saharan African universities. In this sense, there is no research data on the specific contribution that certain dimensions of AI technology can make to sustainable learning outcomes and institutional competitiveness in the Sub-Saharan African higher education context. This research paper is aimed to fill this gap.

METHODOLOGY

A mixed-method research design was used in this study whereby qualitative and quantitative research designs were used together to give an in-depth understanding of AI technology integration and its impacts on sustainable learning outcomes and global competitiveness in Sub-Saharan African higher education. Research approach can be described as the philosophical and methodological stance that guides the gathering and analysis of data while research design provides a procedure through which the data is gathered (Creswell & Creswell, 2018). It was important for this research study to have a mixed-method research design since the problem entailed not only quantitative data collection and analysis but also the qualitative data regarding the experiences, perceptions and challenges of academic staff and students of AI technology integration (Creswell & Plano Clark, 2018).

In this research study, a convergent parallel mixed-method research design was used. In this design, qualitative and quantitative data were collected in approximately the same time period of the research process, analyzed separately using different analytical procedures, and then brought together in the interpretation phase to give a more complete explanation of the research problem (Creswell & Plano Clark, 2018). This design was particularly suitable since this research problem involved determination of the measurable trends in AI technology integration as well as exploration of participants' experiences and perceptions about how AI affects sustainable learning outcomes and global competitiveness.

Study Area

The study was carried out in selected higher education institutions in Sub-Saharan Africa, particularly in East Africa, which comprises Tanzania, Kenya, and Uganda. This geographical location was chosen due to the growing digital transformation in higher education while facing many contextual challenges linked to technological infrastructure,

digital literacy, costs, readiness of institutions, and inequitable access to new technologies. The World Bank (2024) observes that even though the number of people who are digitally connected has risen considerably in Sub-Saharan countries, there are considerable inequalities concerning internet access, affordability, quality of connection, and effective utilization of digital technologies. This means that the region is a good place to investigate the possibility that AI technologies will be able to facilitate sustainable learning and global competitiveness. The choice of Tanzania, Kenya, and Uganda can also be explained by the geographical proximity of these countries, regional similarities, growing higher education sectors, and digital transformation and adoption of new educational technologies. The three countries constitute a good geographical environment in which AI technologies may be integrated since universities function in settings characterized by increasing enrollment of students, digital learning, need for graduates competent in technology, and problems linked to infrastructure and institutional readiness.

Sample Size and Sample Size Determination

The sample size for the quantitative component was determined using the Krejcie and Morgan (1970) approach for determining sample sizes from finite populations. Given an accessible population of 3,840 individuals, the sample size was approximately 351 respondents according to the Krejcie and Morgan table. However, to improve representation and allow for possible non-response, the researcher increased the intended quantitative sample to 384 respondents, consisting of 96 academic staff and 288 students. The sample was proportionately distributed between the two major respondent categories. Academic staff represented 640 out of 3,840 members of the accessible population, while students represented 3,200 out of 3,840. The proportional allocation was calculated as follows:

Data Collection Tools

Two data collection instruments were employed. The first was a researcher-designed questionnaire titled the AI Integration and Global Competitiveness Questionnaire (AIGCQ), which comprised four sub-scales assessing respondents' perceptions of AI's influence on: (i) administrative efficiency; (ii) personalized learning; (iii) automated assessment and feedback; and (iv) global competitiveness. Each

sub-scale contained eight items rated on a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). The questionnaire also included a challenges section comprising 12 items assessing barriers to AI integration.

The second instrument was a semi-structured interview used with 24 purposively selected key informants, comprising 12 academic staff and 12 students, to obtain in-depth qualitative data on their experiences with AI integration, the specific challenges they had encountered, and their perceptions of AI's influence on learning quality and global competitiveness. Interviews were conducted in English and Swahili as appropriate, audio-recorded with participants' consent, and transcribed for analysis.

Data Analysis

Quantitative data from the AIGCQ were entered into SPSS Version 27 and analysed using descriptive statistics, specifically frequencies, percentages, means, and standard deviations. Reliability calculated using Cronbach's Alpha produced the coefficient of 0.89. These statistics were used to determine the extent of AI integration and the level of agreement with items across the four substantive dimensions: administrative efficiency, personalized learning, automated assessment and feedback, and global competitiveness, as well as the challenges section. Descriptive statistics were considered appropriate because they enabled the researcher to summarize the characteristics and response patterns of the study participants in a systematic manner (Field, 2018).

Presentation of Findings

This section presents the findings in relation to the three research questions of the study. The quantitative findings are presented through five tables covering the four substantive dimensions of AI integration administrative efficiency, personalized learning, automated assessment and feedback, and global competitiveness and the challenges of AI implementation. Each table is accompanied by qualitative insights drawn from the interview data to provide contextual richness and triangulated interpretation.

Impact of AI Technologies on Sustainable Learning Outcomes in Higher Education Institutions in Sub-Saharan Africa

This is the first objective in this study, the presentation of this study divided into four aspects in order to get more understanding of the study:

AI Technologies and Administrative Efficiency

This is the first objective in this study which intends to investigate the impact of AI technologies in administrative efficiency. Therefore, table 1 presents respondents' perceptions of the influence of AI technologies on administrative efficiency in higher education institutions in Sub-Saharan Africa.

Table 1: Respondents' Perceptions of AI Technologies and Administrative Efficiency (n = 384)

Item	SD	D	N	A	SA	Mean
AI-powered administrative systems reduce bureaucratic delays in student registration and academic record management.	2(0.5)	8(2.1)	24(6.3)	178(46.4)	172(44.8)	4.33
AI tools improve the speed and accuracy of timetabling, resource allocation, and institutional scheduling.	3(0.8)	10(2.6)	28(7.3)	175(45.6)	168(43.8)	4.29
AI-driven data analytics enable university management to make evidence-based institutional decisions.	2(0.5)	9(2.3)	22(5.7)	180(46.9)	171(44.5)	4.33
AI integration in administrative systems frees academic staff from routine tasks, enabling greater focus on teaching and research.	4(1.0)	11(2.9)	30(7.8)	176(45.8)	163(42.4)	4.26
Overall, AI technologies significantly improve administrative efficiency in higher education institutions.	2(0.5)	7(1.8)	20(5.2)	182(47.4)	173(45.1)	4.35

Source: Field Survey, 2026

The results shown in Table 1 demonstrate that mean scores for all items are consistently high and range between 4.26 and 4.35 on a five-point scale, being thus in the "high agreement" category above 3.50. The highest mean score of 4.35 was attained in relation to AI improvement of administrative efficiency, and the lowest mean score of 4.26 was noted for AI liberating academic staff from routine tasks. This suggests that the respondents strongly believe in the positive impact of AI technologies on administrative efficiency in higher education organizations. One of the interviewed academic staff members said:

"Since our university introduced the AI-powered student management system, the time we spend on registration, record retrieval, and scheduling has reduced dramatically. What used to take days of administrative back-and-forth now happens automatically, and we can direct our attention to what actually matters teaching and supporting our students. (Academic staff 9, 2026)"

The above findings agree with the results of a global literature survey carried out by Zawacki-Richter et al.

(2019), in which the researchers found that administrative uses of artificial intelligence were among the most effective implementations of AI in higher education institutions across the globe. The present study has added evidence from Sub-Saharan African settings to the globally observed phenomenon, showing that the benefits arising from integrating artificial intelligence in terms of efficiency in administration are not only achievable but also possible despite being in constrained resources environments. To the researcher, the high agreement rate in relation to administrative efficiency probably stems from the simple fact that this area of AI impact is less controversial than other dimensions.

AI Technologies and Personalized Learning

This is the second aspect in the first objective of this study which intends to examine the contribution of AI technologies in personalized learning. Hence, table 2 presents respondents' perceptions of the influence of AI technologies on personalized learning in higher education.

Table 2: Respondents' Perceptions of AI Technologies and Personalized Learning (n= 384)

Item	SD	D	N	A	SA	Mean
AI-powered adaptive learning platforms adjust instructional content to meet individual students' learning pace and needs.	3(0.8)	9(2.3)	26(6.8)	177(46.1)	169(44.0)	4.30
AI tutoring systems provide immediate, personalized feedback that helps students identify and correct their learning gaps.	2(0.5)	8(2.1)	24(6.3)	180(46.9)	170(44.3)	4.32
AI technologies enable lecturers to design differentiated learning experiences that cater to diverse student learning styles.	4(1.0)	12(3.1)	32(8.3)	174(45.3)	162(42.2)	4.25
Personalized AI-supported learning improves student engagement, motivation, and academic achievement.	2(0.5)	9(2.3)	25(6.5)	179(46.6)	169(44.0)	4.31
AI personalization strategies help close the performance gap between high-achieving and at-risk students.	5(1.3)	14(3.6)	35(9.1)	170(44.3)	160(41.7)	4.21

Source: Field Survey, 2026

Table 2 above reveals very high mean ratings for all personalized learning questions, with means between 4.21 and 4.32. Item with the highest mean score was on the effectiveness of AI tutoring systems in giving timely, personalized feedback (Mean = 4.32), whereas the item with the lowest mean score was on AI's role in reducing the achievement gap between high-performing and at-risk students (Mean = 4.21). The lower but still high mean rating of this particular item can be explained by certain doubts held by some respondents about whether or not AI personalization has led to equity in their institutions of learning, especially because of the differences in digital access among Sub-Saharan Africa students.

"When I use the AI study assistant on our learning management system, it asks me questions based on what I have already answered and adjusts the difficulty and content to what I actually need to work on. This is very different from the traditional lecture where the lecturer teaches at the same level for all 200 students in the room. With AI, I feel like the learning is actually for me. (Student 17, 2026)"

This qualitative observation is an excellent example of how the personalization approach revealed through

quantitative results operates and supports the Connectivism theory posited by Siemens. The theory is based on the idea of personalized knowledge building as the key to sustainable learning. Additionally, these results coincide with the research of Uwamariya and Musengimana (2021) conducted in Rwanda and revealing that personalized digital devices led to greater engagement and positive results in students whose teachers had the necessary digital literacy skills to implement such technology. Personalized learning in the classroom is interpreted by the current researcher as a necessity in Sub-Saharan African countries with huge classes, poorly equipped libraries, and few individual tutorial sessions.

AI Technologies and Automated Assessment and Feedback

This is the third part of the first objective in this study which intends to investigate the impact of AI technologies and automated assessment and feedback. Therefore, table 3 presents respondents' perceptions of the influence of AI technologies on automated assessment and feedback in higher education.

Table 3: Respondents' Perceptions of AI Technologies and Automated Assessment and Feedback (n = 384)

Item	SD	D	N	A	SA	Mean
AI-powered automated assessment tools provide faster and more consistent marking of student assignments than traditional methods.	3(0.8)	10(2.6)	27(7.0)	176(45.8)	168(43.8)	4.29
AI feedback systems give students immediate, specific, and actionable guidance that improves the quality of their subsequent work.	2(0.5)	8(2.1)	23(6.0)	181(47.1)	170(44.3)	4.33
Automated AI assessment reduces lecturer workload and enables more frequent formative assessment opportunities for students.	3(0.8)	11(2.9)	29(7.6)	175(45.6)	166(43.2)	4.28
AI assessment tools maintain marking consistency and reduce subjective bias in student evaluation.	4(1.0)	12(3.1)	31(8.1)	173(45.1)	164(42.7)	4.26
Overall, AI-automated assessment and feedback mechanisms improve the quality and fairness of student evaluation in higher education.	2(0.5)	8(2.1)	22(5.7)	182(47.4)	170(44.3)	4.33

Source: Field Survey, 2026

In Table 3, there is evidence of a strong consistency in high agreement in all items in the automated assessment section, which ranges between means of 4.26 and 4.33. The highest mean values obtained for items relating to the benefits of AI giving immediate and specific advice (Mean = 4.33) and AI helping increase the fairness of student assessment (Mean = 4.33). It is clear that participants appreciate the power of AI technology to enhance the efficiency and effectiveness of student assessment and feedback, an outcome with significant implications for sustainable student success, since timely feedback is one of the best ways of enhancing learners' performance, according to educational studies (Hattie & Timperley, 2007). A lecturer noted:

"I teach a course with over 300 students. Before we introduced AI-assisted marking, I spent entire weekends grading assignments, and by the time students got their feedback, many of them had moved on and could no longer use the feedback effectively. Now, with AI grading the first layer and me reviewing for quality, students get feedback within 24 hours, and I can see it actually changes how they approach their next assignment. (Academic Staff 38, 2026)"

The above qualitative evidence shows the effectiveness and quality aspects of automated assessment and confirms the quantitative results while providing an explicit example of the timely feedback process through which automated assessment by AI fosters sustainable learning outcomes. The results support the proposal by Holmes et al. (2022), who state that the use of automated assessment must be supervised by humans for quality control purposes, which is exemplified in the testimony of the lecturer above. The present researcher observes that the consensus on automated assessment by Sub-Saharan African participants could partially be attributed to the critical need for such an approach due to the problem of giving feedback in large classes.

AI Technologies and Global Competitiveness

This is the fourth part of the first objective which aimed to evaluate the impact of AI technologies in global competitiveness. Therefore, table 4 presents respondents' perceptions of the relationship between AI technology integration and the global competitiveness of higher education institutions and students in Sub-Saharan Africa.

Table 4. Respondents' Perceptions of AI Technologies and Global Competitiveness (n = 384)

Item	SD	D	N	A	SA	Mean
AI integration enhances the research capabilities of universities by providing access to global databases and intelligent literature review tools.	3(0.8)	9(2.3)	25(6.5)	178(46.4)	169(44.0)	4.31
Students who learn with AI tools develop digital and analytical competencies that improve their competitiveness in the global graduate labour market.	2(0.5)	7(1.8)	23(6.0)	180(46.9)	172(44.8)	4.33
AI-supported cross-border collaboration tools enable Sub-Saharan African universities to engage in international research partnerships.	4(1.0)	12(3.1)	30(7.8)	174(45.3)	164(42.7)	4.27
Higher education institutions that strategically integrate AI are better positioned to attract international students and academic partnerships.	3(0.8)	10(2.6)	28(7.3)	176(45.8)	167(43.5)	4.29
AI integration in Sub-Saharan African universities is essential for closing the global competitiveness gap with leading international institutions.	2(0.5)	8(2.1)	22(5.7)	181(47.1)	171(44.5)	4.34

Source: Field Survey, 2026

Table 4 shows that there is consistently high agreement in relation to all items on global competitiveness, with means between 4.27 and 4.34. The highest mean value obtained was in regard to the item that indicates the importance of integrating AI in closing the gap in global competitiveness (Mean = 4.34), and secondly in regard to the item which indicates that students gain competitive skills for the labour market through the integration of AI (Mean = 4.33). This strongly reinforces the notion that the participants view AI integration not only as an academic practice but also as an institutional one. An academic manager articulated this perspective:

"We are competing with universities in the United States, the United Kingdom, and China for the best students, the best researchers, and the best international partnerships. Without AI tools that enable our researchers to access global databases, our students to develop world-class digital competencies, and our institutions to operate with the efficiency and quality of the best international universities, we will continue to fall further behind. AI is not a luxury for Sub-Saharan

African universities it is a strategic imperative. (Academic staff 24, 2026)"

This insightful revelation clearly shows the need that lies behind the high level of agreement concerning global competitiveness, thus providing support for the main theory of this research. It corresponds with the claims made by Marginson (2022), who asserts that for higher education institutions to become competitive globally, they have to leverage their technological and pedagogical resources so that they are able to compete in terms of research and graduates on an international level. The finding that the use of AI contributes significantly towards enhancing the competitiveness of Sub-Saharan African universities as suggested by this research confirms that AI deployment is imperative for such institutions in order to remain competitive.

Challenges that Hinder the Effective Implementation of AI Technologies in Higher Education in Sub-Saharan Africa

Table 5 presents respondents' perceptions of the challenges that hinder the effective implementation of

AI technologies in higher education institutions in Sub-Saharan Africa.

Table 5 Respondents' Perceptions of Challenges to AI Integration in Higher Education (n = 384)

Item	SD	D	N	A	SA	Mean
Limited ICT infrastructure and unreliable internet connectivity hinder effective AI integration.	5(1.3)	12(3.1)	20(5.2)	170(44.3)	177(46.1)	4.31
Low digital literacy among academic staff limits their ability to effectively deploy AI tools in teaching.	4(1.0)	10(2.6)	22(5.7)	173(45.1)	175(45.6)	4.32
The high cost of AI platforms and tools makes them inaccessible to many Sub-Saharan African universities.	6(1.6)	14(3.6)	25(6.5)	168(43.8)	171(44.5)	4.26
Concerns about reduced critical thinking and over-dependence on AI are significant barriers to faculty adoption.	5(1.3)	13(3.4)	27(7.0)	169(44.0)	170(44.3)	4.26
Absence of clear institutional AI policies and governance frameworks limits the scope and consistency of AI integration.	4(1.0)	11(2.9)	23(6.0)	172(44.8)	174(45.3)	4.30
Concerns about data privacy, algorithmic bias, and academic integrity undermine trust in AI tools among staff and students.	5(1.3)	12(3.1)	26(6.8)	170(44.3)	171(44.5)	4.28

Source: Field Survey, 2026

The results presented in Table 5 suggest that the mean scores of all six challenges were relatively high and varied between 4.26 and 4.32, demonstrating that all of the selected challenges were viewed as important obstacles by the participants of the study. As seen, the highest mean score corresponded to a lack of digital literacy among university lecturers (Mean = 4.32). Next in terms of the mean score was poor ICT infrastructure and poor internet connectivity (Mean = 4.31), while the third most pressing issue in this context was related to a lack of AI policies (Mean = 4.30). Additionally, lower scores of critical thinking and privacy issues also received high mean scores of 4.26 and 4.28, respectively. A student articulated the infrastructure challenge:

"Sometimes I am in the middle of using an AI tool for my research assignment and the internet goes down or the power cuts off. This is very frustrating because the AI system loses my session and I have to start again. If we cannot have reliable electricity and internet, the AI tools are not useful for us no matter how good they are. (Student 2, 2026)"

The above statement shows how the problem of lack of necessary infrastructure was highlighted in the results of the study and it represents a structural problem common to many institutional setups in Sub-Saharan Africa. The results of the present study corroborate the findings by Ndukwe and Daniel (2020) in Nigeria and Mugo and Muthee (2021) in Kenya who reported that infrastructure limitations and employees' poor knowledge of using technology were the major structural issues hindering technology adoption at Sub-Saharan African universities. From the perspective of the present researcher, the consistent mean scores of challenges suggest that the problems related to AI adoption in Sub-Saharan Africa are systemic.

RESULTS AND DISCUSSIONS

The Impact of AI Technologies on Sustainable Learning Outcomes in Higher Education Institutions

The findings of this study demonstrate that AI technologies, when integrated into higher education institutions in Sub-Saharan Africa, are perceived to contribute significantly to sustainable learning outcomes across four dimensions: (i) administrative efficiency, (ii)

personalized learning, (iii) automated assessment and feedback, and (iv) global competitiveness. Across Tables 1-4, the mean scores ranged from 4.21 to 4.35, indicating a high level of agreement among respondents. The percentage distributions further demonstrate that the high mean scores were supported by substantial proportions of respondents who selected either agree or strongly agree on each statement. Thus, the findings provide both statistical and descriptive evidence that respondents perceived AI integration as an important contributor to institutional effectiveness and sustainable learning outcomes.

AI Technologies and Administrative Efficiency

According to the findings in Table 1, there is very high agreement that AI technologies enhance the efficiency of administration in higher education institutions. In relation to the statement that AI-based administrative systems cut down bureaucratic delays in student registration and academic record management, the number of respondents who agreed and strongly agreed was 350 (91.2%), those who disagreed and strongly disagreed was 10 (2.6%) while 24 respondents (6.3%) were neutral. The mean score of 4.33 also shows high agreement. On the same note, 343 respondents (89.4%) agreed or strongly agreed that AI tools increase the speed and accuracy of timetabling, resource allocation, and institutional scheduling, with a mean of 4.29.

In addition, the findings have shown that 351 respondents (91.4%) agreed or strongly agreed that AI-based data analytics help university management to make evidence-based institutional decisions, with a mean score of 4.33. Also, 339 respondents (88.2%) agreed or strongly agreed that AI technology frees academic staff from administrative tasks enabling them to concentrate more on teaching and research, with a mean of 4.26. Overall, the assessment was very high, as 355 respondents (92.5%) agreed or strongly agreed that AI technologies greatly improve administrative efficiency in higher education institutions with the highest mean score of 4.35.

It is clear that the perceived value of AI in terms of administrative efficiency is not based on average scores alone since it is evident in the high proportion of respondents who selected the category of agreement. Further evidence from the qualitative analysis confirms this point as a lecturer noted that the adoption of AI-based student management system significantly reduced time consumed during registration, record searching and scheduling. This shows that AI can reduce

administrative workload and allow academic staff to focus more on teaching, research and supporting students.

The findings agree with Zawacki-Richter et al. (2019) who pointed out administrative applications as one of the critical areas of AI application in higher education. The present study builds on this evidence through showing that the respondents in Sub-Saharan African higher education institutions also see AI as a mechanism for reducing administrative delays and improving institutional decision making. This high level of agreement could also be attributed to the administrative pressure that institutions dealing with many students go through since manually it can cause delays in registration, record management, scheduling, and communication.

AI Technologies and Personalized Learning

The findings in Table 2 suggest that respondents strongly felt that the use of AI technologies enhanced the provision of personalized learning. Regarding the statement that AI-based adaptive learning systems modify teaching content according to individual learners' pacing and needs, 346 respondents (90.1%) indicated their agreement or strong agreement, with a mean of 4.30. Concerning AI tutors providing instant feedback that is used to fill in individual learners' knowledge gaps, 350 respondents (91.2%) agreed or strongly agreed. This statement achieved the highest mean in the dimension at 4.32.

Also, the findings suggest that 336 respondents (87.5%) agreed or strongly agreed that AI provides lecturers with opportunities to create different learning experiences for learners with different learning needs, with a mean of 4.25. Moreover, 348 respondents (90.6%) agreed or strongly agreed that AI-based personalized learning enhances the engagement, motivation, and academic achievements of learners, generating a mean of 4.31. The statement regarding the capacity of AI personalization strategies to reduce the performance gap between high performers and at-risk learners received 330 respondents (86.0%) who agreed or strongly agreed, with a mean of 4.21. Despite being the lowest mean in Table 2, there was a relatively high proportion of people who agreed or strongly agreed.

These findings show that respondents acknowledged the role of AI in providing learning experiences tailored to individual learners' needs. However, the relatively lower level of agreement on reducing achievement gaps shows that respondents felt slightly unsure about the extent to

which AI personalization will be able to bridge the performance gaps between high performers and academically at-risk learners automatically. This might be due to the difference in terms of having access to reliable technological devices and connectivity.

The qualitative data confirm the quantitative analysis results. As reported by a postgraduate student, an AI-based learning assistant adapted the questions and learning material according to previous answers and personal requirements. This is an example of how AI can offer opportunities for differentiation that cannot be provided using the traditional teaching approach, especially at those institutions where students attend classes in large numbers.

The results agree with Uwamariya and Musengimana (2021) who found that a personalized digital learning approach could lead to better engagement and educational outcomes if teachers had appropriate digital skills. These results are also relevant for applying the Connectivism theory as they show that learners can easily access, connect, and continuously construct their knowledge using digital networks. Thus, in Sub-Saharan African higher education, personalized AI-based learning might be used as an approach to dealing with large groups of students and lack of personalized assistance.

AI Technologies and Automated Assessment and Feedback

The results presented in Table 3 reveal a high level of agreement on the role of AI in automated assessment and feedback. Thus, 344 participants (89.6%) agreed and strongly agreed that AI-assisted assessments deliver faster and more consistent marking than the conventional ones, which gives the average result of 4.29. In addition, 351 people (91.4%) agreed and strongly agreed that AI feedback systems allow delivering immediate, specific and actionable feedback which improves students' performance. This statement received an average score of 4.33.

Moreover, 341 participants (88.8%) agreed and strongly agreed that automation of AI assessment decreased workload of the lecturer and provides more opportunities for conducting formative assessment, receiving an average score of 4.28. It should be stated that 337 people (87.8%) agreed and strongly agreed that the AI assessment systems ensure consistency of the marking process and minimize subjective biases, receiving the average score of 4.26. Also, 352 people (91.7%) agreed and strongly agreed that AI-automated assessment and

feedback increase the quality and objectivity of the evaluation, receiving an average score of 4.33.

The similarity between the percentages and the average scores proves that the positive assessment of the AI-supported assessment has been generally recognized by the participants. It is especially valuable that the high percentage of agreement on the topic of the immediate feedback has been identified since it allows identifying the weaknesses of the students and making necessary changes before conducting new learning activities. This is confirmed by the qualitative data: one of the senior lecturers has mentioned that AI-assisted marking decreased the time of the assessment process.

Such results coincide with the ideas proposed by Hattie and Timperley (2007) regarding the role of good feedback in increasing effectiveness in learning. These results also agree with Holmes et al. (2022), who state that AI assessment should always be performed under the proper supervision by a person. The case of the lecturer in the current research also proves the human-AI tandem, in which the AI is helping with the preliminary assessment and the lecturer performs the function of quality control.

Such results prove that automatic assessment cannot be considered an absolute replacement of academic evaluation. The main advantage of such technology may consist in relieving a person from repetitive assessment work and making it possible for lecturers to pay attention to the analysis of the results and provision of additional help.

AI Technologies and Global Competitiveness

The findings as presented in Table 4 reveal that the survey participants had a high degree of association between AI integration and competitiveness of higher education at the global level. 347 respondents (90.4%) concurred that integration of AI helps enhance research capacity at the universities by making global databases and intelligent tools for literature review accessible, and this yielded a mean score of 4.31. Similarly, 352 respondents (91.7%) concurred that students educated using AI tools acquire digital and analytical skills which increase their competitiveness in the global graduate job market. This yielded a mean score of 4.33. Furthermore, the results reveal that 338 respondents (88.0%) concurred that AI-driven cross-border collaboration tools help Sub-Saharan African universities to be part of global research collaborations, with a mean score of 4.27. Additionally, 343 respondents (89.3%) agreed or strongly agreed that institutions adopting AI strategically are well-

placed to attract international students and academic collaborations, and this yielded a mean score of 4.29.

The strongest findings in Table 4 were found for the assertion about the necessity of AI integration in closing the gap of international competitiveness between Sub-Saharan African universities and the best foreign institutions. 352 respondents (91.6%) agreed or strongly agreed that the integration of AI in teaching-learning processes is crucial in addressing this issue. As a result, the mean value of agreement with this statement was the highest in Table 4 – 4.34. The findings imply that AI integration could be perceived not only as an advanced technology to use in classrooms but also as a resource to improve research potential, international cooperation, graduate employment, and university's prestige.

The qualitative data prove this interpretation. A faculty dean noted that the universities of Sub-Saharan Africa compete internationally on students, researchers, and collaboration with academic partners and that AI allows having global database access, developing digital skills and increasing efficiency of institutions. This understanding coincides with the idea of Marginson (2022) about the necessity of investing in technological and pedagogical skills that would allow institutions functioning in international level.

The results concerning students' digital and analytical competencies are especially important because their application goes beyond the direct learning process. Over nine out of ten respondents (91.7%) agreed that AI integration helps in acquiring skills that make students more competitive in international job markets. It means that AI implementation may contribute to human capital development by preparing graduates for workplaces where digital technologies, analytical skills and international communication become integral aspects. The interpretation is confirmed by the opinion of UNESCO (2021) that sustainable learning outcomes must involve digital, analytical and collaborative competencies.

Challenges that Hinder the Effective Implementation of AI Technologies in Higher Education

The findings in Table 5 reveal that respondents simultaneously recognized the benefits of AI and the substantial challenges that hinder its effective implementation. All six identified challenges recorded high mean scores, ranging from 4.26 to 4.32. The percentage distributions similarly demonstrate that large majorities of respondents agreed or strongly agreed that each challenge represents a significant barrier to AI

integration. Low digital literacy among academic staff was the most strongly endorsed challenge. 348 respondents (90.7%) agreed or strongly agreed that low digital literacy limits academic staff's ability to effectively deploy AI tools in teaching, producing a mean score of 4.32. Limited ICT infrastructure and unreliable internet connectivity were identified by 347 respondents (90.4%), who agreed or strongly agreed that these conditions hinder effective AI integration. This challenge recorded a mean of 4.31.

The absence of clear institutional AI policies and governance frameworks was also strongly endorsed, with 346 respondents (90.1%) agreeing or strongly agreeing that inadequate policies limit the scope and consistency of AI integration. The mean score for this item was 4.30. Concerns about data privacy, algorithmic bias, and academic integrity were endorsed by 341 respondents (88.8%), with a mean score of 4.28. Similarly, 339 respondents (88.3%) agreed or strongly agreed that the high cost of AI platforms and tools makes them inaccessible to many Sub-Saharan African universities, resulting in a mean score of 4.26. Concerns about reduced critical thinking and overdependence on AI were also strongly endorsed, with 339 respondents (88.3%) agreeing or strongly agreeing that these concerns represent significant barriers to faculty adoption. This item recorded a mean of 4.26.

The high percentages of agreement indicate that the challenges are not isolated concerns held by a small group of respondents. Rather, they represent widely shared perceptions across the study participants. The findings therefore portray AI implementation as a process characterized by both considerable potential and significant structural, financial, pedagogical, ethical, and policy constraints. The concern regarding reduced critical thinking is particularly important for sustainable learning outcomes. Although its mean score of 4.26 was slightly lower than those for digital literacy and infrastructure, 88.3% of respondents agreed or strongly agreed that overdependence on AI and reduced critical thinking constitute significant barriers. This suggests that respondents were aware of the possibility that students may use AI as a substitute for independent intellectual engagement rather than as a tool that supports deeper learning.

This concern is consistent with Holmes et al. (2022), who emphasized the need to ensure that AI in education strengthens rather than undermines learner agency and critical thinking. The implication from the present findings is that the solution should not necessarily be to restrict AI

use but to develop pedagogical approaches that require students to critically evaluate, verify, question, and improve AI-generated outputs. Such an approach would position AI as a learning support rather than a replacement for human reasoning. The infrastructure challenge is further illustrated by the qualitative evidence from an undergraduate student who described interruptions caused by unreliable internet connectivity and electricity. This experience demonstrates that technological innovation cannot produce sustainable learning benefits where the basic infrastructure required to access AI systems remains unreliable. The finding is consistent with evidence from Ng'ambi et al. (2020) in South Africa and Mugo and Muthee (2021) in Kenya, who identified technological infrastructure and digital competencies as important factors affecting technology adoption in African higher education.

Overall, the findings indicate that successful AI integration in Sub-Saharan African higher education requires more than acquiring AI tools. Institutions need to simultaneously strengthen digital infrastructure, improve academic staff digital literacy, establish clear AI policies and governance frameworks, address affordability, and develop mechanisms for protecting academic integrity, data privacy, and critical thinking. The coexistence of very high agreement on both the benefits and challenges of AI integration demonstrates that respondents recognize AI as a potentially transformative technology but understand that its sustainable educational value depends on the institutional conditions under which it is implemented.

CONCLUSIONS

The study concludes that AI technologies can significantly contribute to sustainable learning outcomes in higher education institutions in Sub-Saharan Africa by improving administrative efficiency, personalized learning, automated assessment and feedback, and global competitiveness. AI can reduce administrative workload, provide personalized learning experiences, deliver timely feedback, support research, and develop students' digital and analytical competencies. However, effective AI implementation is constrained by low AI literacy among academic staff, inadequate infrastructure and internet connectivity, high costs of AI tools, limited institutional AI policies, data privacy concerns, academic integrity issues, and the risk of over-dependence on AI and reduced critical thinking. The study therefore recommends that higher education institutions develop clear AI policies, strengthen AI literacy among staff and

students, improve the infrastructure needed for AI applications, ensure equitable access to AI tools, and maintain human oversight of AI-supported assessment and decision-making. Lecturers should use AI to complement rather than replace teaching and critical thinking, while students should use AI responsibly and critically evaluate AI-generated information. Governments and higher education regulators should support AI adoption through appropriate policies, funding, affordable AI access, and partnerships. Future studies should examine the actual effects of AI on academic achievement, engagement, employ-ability, and learning outcomes across different higher education contexts.

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