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POTENTIAL OF AI-DRIVEN VIRTUAL LEARNING ENVIRONMENTS IN AFRICAN HIGHER EDUCATION INSTITUTIONS

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ABSTRACT

Artificial intelligence (AI) has completely changed the educational landscape, inspiring the creation of virtual learning environments (VLEs) powered by AI. These immersive learning environments have revolutionised the way we think about education by giving students individualised, dynamic, and exciting educational experiences. The objectives of the study were to explore the current state of AI-driven VLEs in African higher education institutions **(**AHEI) and to investigate the potential benefits and challenges of implementing AI-driven VLE in AHEI. The study utilized the Unified Theory of Acceptance and Use of Technology (UTAUT) model, the Diffusion of Innovations (DOI) theory and the Theory of Planned Behavior (TPB) which provide valuable framework to understand AI adoption in higher education, enabling educators to design and implement AI-powered tools more effectively. This study employed a comprehensive review approach as the primary data collection method to investigate the adoption and effect of AI-driven VLEs in African Higher Education. The review of existing literature was conducted, encompassing academic journals and published institutional reports. Key search engines and databases, including Google Scholar, Scopus, and Web of Science, were utilized to identify relevant sources. The inclusion criteria were resources of relevance to the research objectives and studies published. The findings demonstrate AI-driven VLEs possess the potential to transform African higher education by increasing access, improving quality, and

enhancing student outcomes. It also highlighted the benefits of AI-driven VLEs, including personalised learning, supporting students with disability and improved student engagement. The challenges encountered include unreliable internet, digital literacy gaps, high costs, and concerns about cultural relevance and equity. The paper recommended that governments and educational institutions should invest in reliable internet connectivity and collaborate with local experts to develop AI-driven VLEs tailored to the unique needs of African students.

***Keywords**: Artificial Intelligence (AI), Digital skills gap, Learning outcomes, Students' Personalised learning and Virtual Learning Environments (VLEs)*

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Introduction

Africa's higher education has a rich history, dating back to the 13th century with universities in Timbuktu and Alexandria (Lulat, 2006). Colonialism disrupted this trajectory by imposing Western knowledge systems and marginalizing indigenous customs (Mamdani, 2016). Today, African higher education faces challenges such as funding shortfalls, brain drain, and political instability (Teferra, 2007). However, significant strides have been made through investments in innovative pedagogies and digital infrastructure (Kwesiga & Chancellor, 2017). The continent now boasts over 1,000 institutions, reflecting its complexity and diversity (Association of African Universities, 2020). Integrating indigenous knowledge systems with Western epistemologies remains an ongoing challenge (Odora-Hoppers, 2009). Despite these hurdles, higher education in Africa holds immense potential to drive social justice, economic growth, and cultural renewal (Jansen, 2018), showcasing the resilience and adaptability of the sector.

In this evolving landscape, AI-driven VLEs represent a cutting-edge shift, promising to address longstanding access to and quality challenges in African higher education. The introduction of AI has transformed the education sector in Africa, leading to the development of AI-driven VLEs. The study aims to:

1. explore the current state of AI-driven VLEs in AHEI
2. explore the potential benefits and challenges of implementing AI-driven VLEs in AHEI

To meet these objectives, the following research questions were asked:

1. What is the current state of AI-driven VLEs in AHEI?
2. What are the potential benefits of AI-driven VLEs in AHEI?
3. How are these benefits influencing AHEI's effectiveness?
4. What are the challenges of implementing AI-driven VLEs in AHEI?
5. How are these challenges being resolved in AI-driven VLEs in AHEI?

The research seeks to provide insights into how AI-driven VLEs can transform African higher education by improving accessibility, personalization, and efficiency while addressing implementation hurdles. The findings could guide policymakers, educators, and institutions in leveraging AI for better educational outcomes.

AI-driven VLEs offer personalised, dynamic, and engaging educational experiences (Kim et al., 2020). AI-powered tools such as chatbots, virtual assistants, learning management systems, intelligent tutoring programs, and educational games are revolutionizing the way students learn (Dziuban et al., 2018; Chi et al., 2011; Shute et al., 2009; Tucker et al., 2020). However, challenges remain, including creating engaging eLearning content, ensuring equitable access to AI-powered resources, and developing accurate grading algorithms (Kim et al., 2020; Khoalenyane & Ajani, 2024).

This study is critical for African higher education institutions as AI-driven VLEs address significant challenges and offer transformative benefits. They help bridge the educational gap between urban and rural areas by providing equitable access to high-quality resources, which is vital given the pronounced disparities in Africa (Kim et al., 2020). Personalised learning experiences facilitated by AI improve student engagement and academic performance by adapting to individual needs (Dziuban et al., 2018). AI also supports educators by enhancing tutorial decisions, allowing them to focus more on teaching and improving student learning outcomes (Chi et al., 2011). Additionally, integrating AI into education enhances assessment and learning processes within intelligent educational systems (Shute et al., 2009), and fosters innovation in teaching methodologies by transforming them, making them more interactive and personalised, which is crucial for the future of STEM education and societal impact (Tucker et al., 2020).

This study is significant because it contextualizes AI-driven VLEs for Africa, offering evidence-based strategies to harness AI for equitable, scalable, and high-quality education. In addition, it is crucial for African higher education institutions (AHEIs), policymakers, educators, and ed-tech developers as it addresses significant gaps in existing literature and proposes AI-driven VLEs as transformative solutions. It highlights the lack of research on AI-driven VLEs in African contexts, where infrastructure, digital literacy, and socio-economic conditions differ from developed nations. The study identifies unique challenges such as infrastructure limitations, digital literacy gaps, financial constraints, cultural mismatches, and resistance to technological change. By pinpointing these barriers, it provides a roadmap for context-sensitive AI integration. The study demonstrates how AI-driven VLEs can enhance accessibility, support inclusive education, reduce long-term costs, improve engagement, and bridge equity gaps. It urges African governments and institutions to invest in digital infrastructure, develop localized AI solutions, implement digital literacy programs, and foster public-private partnerships. By addressing adoption barriers and proposing tailored solutions, the study contributes to the broader discourse on AI for inclusive and sustainable education in developing regions.

The current literature on AI-driven VLEs in African higher education highlights several key themes and findings. Studies have shown that AI technologies are being integrated into educational systems across Africa to enhance personalised learning experiences, improve administrative processes, and support teaching methodologies. However, challenges such as resource constraints, ethical considerations, and the digital divide remain significant barriers (Khoalenyane &

Ajani, 2024). This study aims to build upon this existing knowledge by providing a comprehensive review of AI-driven VLEs specifically within African higher education institutions. By utilizing the UTAUT model, this study offers a structured framework to understand AI adoption in this context, enabling educators to design and implement AI-powered tools more effectively. Additionally, this study addresses the unique challenges faced by African higher education institutions, such as unreliable internet connectivity and digital literacy gaps, and proposes solutions tailored to the needs of African students.

While AI-driven VLEs offer significant potential to revolutionize higher education in Africa by providing personalised, dynamic, and engaging learning experiences, there are still substantial challenges that need to be addressed. These include creating engaging eLearning content, ensuring equitable access to AI-powered resources, and developing accurate grading algorithms. The study seeks to highlight both the opportunities and the obstacles to provide a comprehensive understanding of the impact of AI in African higher education.

The advent of AI has further revolutionized the sector, particularly through AI-driven VLEs. These technologies offer personalised, dynamic, and engaging learning experiences, although they also present challenges such as creating engaging eLearning content, ensuring equitable access, and developing accurate grading algorithms. This study aims to provide a comprehensive understanding of the current state, benefits, and challenges of implementing AI-driven VLEs in AHEI. By addressing these research questions, the study seeks to highlight both the opportunities and obstacles in leveraging AI to transform education in Africa

THEORETICAL AND LITERATURE REVIEW

In any research study, theoretical and literature review play a crucial role in establishing the foundation and context for the investigation. This section involves a comprehensive examination of existing research and theories related to this study.

Theoretical Review

This study is grounded in three theories: the Unified Theory of Acceptance and Use of Technology (UTAUT) model, the Diffusion of Innovations (DOI) theory and the Theory of Planned Behavior (TPB) which provide a comprehensive framework for understanding the adoption and impact of AI-driven VLEs in AHEIs.

The first is the Unified Theory of Acceptance and Use of Technology (UTAUT) model, a widely recognized framework for understanding technology adoption and usage. The theory has been defined and expanded upon by various scholars. Davis (1989) originally conceptualized technology acceptance as being driven by perceived ease of use and usefulness, laying the foundation for later models. Venkatesh et al. (2003) formalized UTAUT as a comprehensive framework, identifying four key determinants of technology adoption:

1. Performance expectancy – the degree to which a user believes the technology will enhance their performance.
2. Effort expectancy – the perceived ease of using the technology.
3. Social influence – the extent to which others' opinions affect adoption.

4. Facilitating conditions – the availability of resources and support for technology use.

Dwivedi et al. (2019) further elaborated that UTAUT integrates elements from other theories, including the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and the Theory of Reasoned Action (TRA).

UTAUT posits that individuals are more likely to adopt technology if they believe it will improve their efficiency, is easy to use, and is supported by peers and institutional infrastructure (Venkatesh et al., 2003). The model also acknowledges moderating factors such as age, gender, experience, and voluntariness of use that influence adoption patterns (Venkatesh et al., 2003; Dwivedi et al., 2019). An extended version, UTAUT 2, introduced by Venkatesh et al. (2012), incorporates additional constructs such as hedonic motivation (enjoyment), price value (cost-benefit analysis), and habit, recognizing their role in technology adoption.

The UTAUT model has been widely applied in educational contexts to analyze technology adoption, including AI-enabled tools in higher education (Venkatesh et al., 2003), see Table 1. for clarity. The four core constructs help explain students' and educators' acceptance of AI-powered solutions:

Performance Expectancy – Students and educators are more likely to adopt AI tools if they believe they enhance learning outcomes or teaching efficiency (Wang et al., 2020; Al-Shammari & Rosli, 2020). For instance, students may expect improved learning outcomes and personalised learning experiences, while educators may anticipate more efficient teaching processes and better student engagement.

Effort Expectancy – Perceived complexity affects adoption; educators embrace AI if it reduces workload, whereas students may resist if tools seem cumbersome (Al-Shammari & Rosli, 2020; Wang et al., 2020). If students and educators find these systems user-friendly and intuitive, they are more likely to adopt them. Simplified interfaces and accessible resources can reduce the perceived effort required to use AI tools.

Social Influence – Peer, instructor, or institutional encouragement significantly impacts adoption (Wang et al., 2020; Al-Shammari & Rosli, 2020). In AHEI, the encouragement from peers, educators, and administrators can significantly influence the acceptance of AI-driven VLEs. Positive testimonials and shared experiences can foster a supportive environment for AI adoption.

Facilitating Conditions – Access to training, technical support, and infrastructure is critical for successful AI integration (Al-Shammari, 2023; Wang et al., 2020). Reliable internet connectivity, technical support, and training programs are crucial for successful implementation. Addressing infrastructure challenges and providing adequate support can enhance the adoption of AI technologies.

By applying UTAUT, higher education institutions can design AI solutions that align with user expectations, thereby improving adoption rates. Understanding these factors enables policymakers and developers to create strategies that enhance AI integration in academic settings.

Table 1: Framework of UTAUT in the context of this study

UTAUT Constructs	Key Factors Influencing Adoption
Performance Expectancy	Clear benefits in improved learning outcomes and efficiency - academic performance, personalised learning experiences, and enhanced engagement
Effort Expectancy	Simplified user interface Adequate training provided
Social Influence	Encouragement from peers and institutional leaders
Facilitating Conditions	Access to necessary infrastructure e.g. reliable internet, modern computing facilities and technical support Professional development for educators

The second theory that underpins the study is the Diffusion of Innovations (DOI) theory. Proposed by Everett Rogers (1962), this theory explains how innovations are adopted or new technologies and ideas spread within a social system over time. It also explains how, why, and at what rate new ideas and technologies spread through cultures. The DOI theory (Rogers, 2003) provides a valuable framework for analyzing the adoption patterns, barriers, and strategies for implementing AI-driven VLEs in AHEI. According to DOI, the rate of adoption of an innovation depends on five key attributes. The attributes and how it's applied in the study are discussed.

Relative advantage is the degree to which the innovation is perceived as better than the idea it supersedes. The degree to which AI-driven VLEs are perceived as better than traditional teaching methods is worth noting. Studies show that AI-enhanced learning tools offer benefits such as personalised learning, accessibility for students with disabilities, and improved engagement, making them attractive to educators (Luckin et al., 2016; Zawacki-Richter et al., 2019).

Compatibility involves how consistent the innovation is with the existing values, past experiences, and needs of potential adopters. The extent to which AI-driven VLEs align with existing educational values, infrastructure, and cultural contexts explains its compatibility. Challenges such as digital literacy gaps, cultural relevance, and infrastructure limitations must be addressed to enhance adoption (Tarus et al., 2015; Mtebe & Raisamo, 2014).

Complexity refers to how difficult the innovation is to understand and use. The perceived difficulty in using AI-driven VLEs shows its complexity. Barriers such as lack of technical expertise and high costs hinder adoption (Scherer et al., 2019). DOI suggests that simpler innovations are adopted faster, necessitating training programs and user-friendly AI tools (Rogers, 2003).

Trialability shows the extent to which the innovation can be experimented with on a limited basis. The ability to experiment with AI-driven VLEs on a limited scale is

essential before its adoption in this resource constrained environment. Pilot programs and collaborations with local experts can facilitate gradual adoption (Al-Emran et al., 2020).

Lastly, observability refers to the extent to which the results of the innovation are visible to others. The visibility of AI-driven VLE benefits, such as improved student engagement and accessibility. Success stories encourage wider adoption (Rogers, 2003; Ifinedo, 2018).

Based on DOI Theory (see Table 2), there is therefore a need to invest in infrastructure (e.g., reliable internet) to support AI-VLE diffusion (Tarus et al., 2015). Secondly, developing training programs to reduce complexity and improve digital literacy (Scherer et al., 2019) should be implemented. The creation of localized AI solutions to enhance compatibility with African educational needs (Mtebe & Raisamo, 2014) is also imperative. Thus, implementing pilot testing and gradual scaling to demonstrate observable benefits (Al-Emran et al., 2020) is in the right direction to influence AI-driven VLEs spread and sustainability.

Table 2: Framework of Diffusion of Innovations (DOI) theory in the context of this study

DOI Attribute	Application in Study
Relative Advantage	AI-driven VLEs offer personalised learning, accessibility for students with disabilities, and improved engagement
Compatibility	Aligns with educational values, infrastructure, and cultural contexts; addresses digital literacy gaps and infrastructure limitations
Complexity	Perceived difficulty due to lack of technical expertise and high costs; simpler innovations adopted faster
Trialability	Essential for adoption in resource-constrained environments; pilot programs and collaborations facilitate gradual adoption
Observability	Visible benefits like improved student engagement and accessibility encourage wider adoption

The Theory of Planned Behaviour (TPB) (Ajzen, 1991) is the last theory that underpins this study. It provides a robust framework for understanding the factors influencing educators' and students' intentions to adopt AI-driven VLEs. According to TPB, behavioral intention, the strongest predictor of actual behavior, is shaped by three key determinants: attitudes toward the behavior, subjective norms and perceived behavioral control.

Attitudes toward the behavior refers to the individual's positive or negative evaluation of performing the behavior. If a person believes that engaging in a particular behavior will lead to favorable outcomes, they are more likely to have a positive attitude towards it. For this study, if educators and students perceive AI-enhanced learning tools as beneficial (e.g., personalised learning, efficiency), they are more likely to adopt them (Teo et al., 2018). Educators' perceptions of AI's

usefulness in grading, feedback, and adaptive learning can shape their willingness to use it (Luckin et al., 2016).

Subjective norms are the perceived social pressures to perform or not perform the behavior. It involves the influence of people important to the individual, such as family, friends, or colleagues, and whether they approve or disapprove of the behavior. Its application in this study refers to the perceived social pressure from peers, administrators, or institutions to use AI-driven VLEs. If key stakeholders (e.g., colleagues, policymakers) endorse AI in education, individuals are more likely to adopt it (Scherer et al., 2019). Institutional policies mandating AI integration or peer recommendations can drive adoption (Venkatesh et al., 2012).

Perceived Behavioral Control (PBC) is the factor that reflects the individual's perception of their ability to perform the behavior. It includes the presence of factors that may facilitate or hinder the behavior, such as resources, opportunities, and skills. The individual's belief in their ability to use AI-driven VLEs is influenced by factors such as technical skills, training, and institutional support (Ifinedo, 2018). Higher PBC increases adoption likelihood. Thus, the availability of training and technical infrastructure influences confidence in using AI tools (Dwivedi et al., 2019). There by applying TPB, researchers can identify key barriers and facilitators in AI-driven VLE adoption, helping policymakers design targeted interventions. This framework also ensures a structured analysis of psychological and social factors affecting AI-driven VLE adoption (see Table 3).

Table 3: Framework of The Theory of Planned Behavior (TPB) in the context of this study

TPB Attribute	Application in Study
Attitudes Toward the Behavior	Educators and students are more likely to adopt AI-enhanced learning tools if they perceive them as beneficial (e.g., personalised learning, efficiency)
Subjective Norms	Perceived social pressure from peers, administrators, or institutions to use AI-driven VLEs; endorsement by key stakeholders drives adoption
Perceived Behavioral Control (PBC)	Belief in one's ability to use AI-driven VLEs influenced by technical skills, training, and institutional support; higher PBC increases adoption likelihood

The integration of UTAUT, DOI theory, and TPB provides a comprehensive framework for understanding the adoption and impact of AI-driven VLEs in AHEIs. UTAUT helps identify key determinants such as performance expectancy, effort expectancy, social influence, and facilitating conditions, which influence technology acceptance. DOI theory explains the spread of AI-driven VLEs, highlighting the importance of innovative attributes, communication channels, and social systems. TPB offers insights into the role of individual attitudes, subjective norms, and perceived behavioral control in shaping behavioral intentions towards AI adoption. Together, these theories enable a nuanced analysis of the factors affecting the implementation and usage of AI-driven VLEs, providing valuable guidance for educators and policymakers to design effective strategies that

enhance educational outcomes and address challenges in African higher education.

Literature review

The integration of AI in education has garnered significant attention in recent years. By synthesizing existing research, this review will highlight key applications, benefits, and limitations of AI in educational settings.

Virtual learning environments (VLEs)

VLEs are web-based platforms that facilitate online education by providing tools for content delivery, communication, assessment, and collaboration to enhance learning experience for both students and educators. With the rapid advancement of digital technologies, VLEs have become integral to both traditional and distance education.

Virtual Learning Environments (VLEs), also known as Learning Management Systems (LMS), are digital platforms where educators and students engage and collaborate. The first VLEs appeared in the late 1990s, with notable examples like Blackboard and Moodle (Coates et al., 2005). These systems have evolved to include multimedia content, social learning features, and artificial intelligence (Dillenbourg et al., 2009). Today's VLEs, such as Canvas, Google Classroom, and Microsoft Teams, leverage cloud computing, offer mobile accessibility, and incorporate gamification elements (Alario-Hoyos et al., 2017).

VLEs, which offer creative and adaptable methods to deliver and access education, have completely changed the face of higher education (Garrison, 2022). They facilitate the creation, storage, and dissemination of educational content, course planning, and communication between students and instructors. These environments can include features such as discussion forums, quizzes, and real-time interactions, making them a comprehensive tool for modern education (Coursera, 2024).

The key features of VLEs are content management in which VLEs allow educators to upload and organize course materials, making it easy for students to access lectures, readings, and assignments. There are also communication tools, with platforms including email, chat, and discussion forums to facilitate interaction between students and instructors. Assessment and feedback is another key feature where VLEs can automate quizzes and assignments, providing immediate feedback to students. The last feature is flexibility, where VLEs support both synchronous (real-time) and asynchronous (self-paced) learning, catering to different learning styles and schedules (Coursera, 2024).

The features of VLEs offer numerous benefits, which are particularly evident in universities. Universities now depend heavily on VLEs as a means of expanding their reach, improving accessibility, and improving student learning (Moore et al., 2024). VLEs allow learners to access materials anytime, anywhere, supporting self-paced learning (Means et al., 2013). This is particularly beneficial for working professionals and students in remote areas. Despite physical distance, one of the main benefits of VLEs is their capacity to provide students with a sense of belonging and community. According to Shea (2007), virtual classrooms, discussion boards, and collaboration tools promote social presence and a sense of

belonging by facilitating connection and involvement. Shea (2007) conducted research, for example, and discovered that students who took part in online conversations had greater levels of engagement and happiness than their non-participating peers.

Additionally, personalised learning experiences are provided by VLEs, enabling students to access resources that are specifically suited to meet their requirements and learn at their own speed (Dziuban et al., 2018). AI-driven VLEs adapt content based on learner performance, offering personalised pathways (Luckin et al., 2016). Teachers may monitor students' progress, pinpoint areas for growth, and offer focused assistance with the use of adaptive technology and learning analytics (Siemens, 2012). For instance, Dziuban et al.'s (2018) study discovered that adaptive learning systems raised student engagement and enhanced learning results.

One other benefit is the integration of AI in VLEs which has transformed the higher education landscape in Africa, offering innovative and flexible ways to deliver and access education (Garrison, 2022). AI-driven VLEs have the potential to address some of the challenges facing African higher education, such as limited access, high student-to-teacher ratios, and inadequate infrastructure (Moore, 2024). Currently, AI-driven VLEs are being used in some African universities to provide personalised learning experiences, automate grading, and enhance student engagement (Dziuban et al., 2021). For instance, the University of South Africa's (UNISA) AI-powered VLE provides students with personalised learning materials and adaptive assessments (UNISA, 2020).

Moreover, VLEs have improved accessibility and inclusivity of higher education, especially for students with impairments, students from different geographic regions, and students with competing obligations (Moore, 2024). By offering immersive and interactive learning possibilities, virtual laboratories, simulations, and virtual reality experiences improve the educational process (Crompton et al., 2024). For example, research conducted in 2017 by Crompton discovered that virtual reality experiences enhanced student engagement and learning results. With regards to enhanced engagement, interactive features such as discussion forums, quizzes, and video lectures improve engagement (Sun et al., 2008). In addition, gamification elements (badges, leaderboards) further motivate learners (Deterding et al., 2011).

While these benefits have a significant positive impact on AHEI, there are challenges, such as maintaining social interaction. VLEs can lead to feelings of isolation as students miss out on face-to-face interactions, which are crucial for developing social skills and a sense of community (Kahu, & Nelson, 2017). There are technical issues too related to unreliable internet and technology access causing disruptions and frustration (National University, 2021). The issue of self-motivation and time management can be a challenge for students. VLEs require high levels of self-discipline and time management, which can be challenging for some students (Wolters & Brady, 2021). Moreover, there may be limited feedback for students. Online learning may limit the immediacy and personalization of feedback compared to traditional classroom settings (E-Student, 2023). Cheating and academic integrity have come to play in higher education assessments currently. Ensuring academic integrity is more challenging in virtual environments, requiring robust monitoring solutions (Sabrina et al., 2022).

Accessibility issues are more profound in Africa. Not all students have equal access to necessary technology and internet connectivity, exacerbating educational inequalities (Moore et al., 2018). The lack of infrastructure and internet connectivity in many African countries also limits access to VLEs (International Telecommunications Union (ITU), 2024). Additionally, there is a shortage of skilled educators and technicians who can design and implement AI-driven VLEs (Shchetyna, 2023). Another challenge is the need for culturally relevant and inclusive AI-driven VLEs that consider the diverse needs and contexts of African students (Crompton et al., 2024). Furthermore, there are concerns about data privacy and security (Chen, 2024), as well as the potential for AI to replace human teachers (Gašević et al., 2023).

To address these gaps in VLEs, strategies should focus on enhancing social interaction to mitigate isolation, improving technical infrastructure for reliable internet access, and developing tools to support self-motivation and time management. Additionally, implementing systems for immediate and personalised feedback, ensuring academic integrity through advanced monitoring solutions, and bridging the digital divide are crucial. Training educators and technicians to effectively use AI-driven VLEs and creating culturally relevant, inclusive content tailored to diverse student needs will further enhance the effectiveness of VLEs in higher education.

Applications of AI-Driven Virtual Learning Environments (VLEs)

Education has undergone a revolution thanks to AI, which has altered how we assess, learn, and teach students. By providing successful, individualized, and productive learning experiences, AI has the potential to drastically change the education sector (Luckin et al., 2024). One of the key applications of AI in education is adaptive learning. AI-powered adaptive learning systems adjust the course materials' level of complexity based on each student's performance to provide a personalised learning environment (Dziuban, 2018). It has been shown that applying this tactic can improve learning outcomes and increase student engagement (Chi et al., 2011).

Furthermore, chatbots and virtual assistants driven by AI are being used to assist students with their inquiries, freeing up teachers to focus on more challenging issues (Kim et al., 2020). AI can evaluate and offer comments on student writing using Natural Language Processing (NLP), which helps students' writing abilities (Wang et al., 2021). Additionally, by offering individualized accommodation and assistance, AI has the potential to improve accessibility for students with impairments (Anderson, 2018). Also, enhanced accessibility is provided, that is AI technologies, such as speech recognition and text-to-speech, can support students with disabilities, making learning materials more accessible and inclusive (Arias-Flores et al., 2025). This implies that both personalised learning and support for students with disabilities are about customizing the learning experience to meet individual needs. By leveraging AI, VLEs can create an inclusive environment where all students, regardless of their abilities, can access and engage with educational content in a way that suits them best. This holistic approach ensures that every student receives the support they need to thrive academically.

In addition, we have the Intelligent Tutoring Systems (ITS) which is an AI-driven ITS that provides personalised instruction and feedback to students, simulating one-on-one tutoring. These systems can identify areas where students struggle

and offer targeted support to improve understanding and retention (VanLehn, 2011). The automated grading and feedback is also used in higher education institutions where AI can automate the grading of assignments and exams, providing consistent and objective evaluations. This reduces the workload on educators and allows for quicker feedback to students (Balfour, 2013).

Conversely, we have predictive analytics. Here the AI can analyze student data to predict academic performance and identify at-risk students. This enables institutions to intervene early and provide necessary support to improve student outcomes (Arnold & Pistilli, 2012). The virtual assistants are also worth mentioning. These AI-powered virtual assistants can help students with administrative tasks, such as scheduling, reminders, and answering frequently asked questions. This enhances the overall student experience and allows educators to focus more on teaching (Okonkwo & Ade-Ibijola, 2021). Although AI has the potential to revolutionise education, its research, and application must be handled responsibly.

AI-driven VLEs offer major benefits but face several gaps. Personalization through adaptive learning improves engagement and outcomes (Luckin et al., 2024; Dziuban, 2018), yet over-reliance on AI can neglect curriculum standards and affect collaborative skills. AI enhances accessibility for students with disabilities (Arias-Flores et al. 2025; Anderson, 2018), but socioeconomic disparities limit access, widening the digital divide. Intelligent Tutoring Systems (ITS) provide personalised tutoring (VanLehn, 2011) but may reduce human interaction and lack emotional intelligence. Automated grading offers quick feedback (Balfour, 2013) but struggles with subjective assessments and potential biases. Predictive analytics identify at-risk learners (Arnold & Pistilli, 2012), raising ethical concerns about bias and privacy. Virtual assistants improve efficiency (Okonkwo & Ade-Ibijola, 2021), but over-automation can reduce problem-solving skills. Research gaps include limited longitudinal studies on AI's long-term impact, lack of teacher training programs for AI-integrated classrooms, and the need for ethical policy frameworks to regulate AI use in education. Addressing these gaps is crucial for maximizing the effectiveness of AI-driven VLEs in enhancing learning experiences.

Methodology

This study employed a comprehensive review approach as the primary data collection method to investigate the adoption and effect of AI-driven VLEs in AHEI. A comprehensive review approach systematically collects, evaluates, and synthesizes existing research on a specific topic. It aims to provide a detailed and unbiased summary of the current state of knowledge, identify gaps in the literature, and suggest areas for future research (Taherdoost, 2022).

In conducting a comprehensive review for this study, several systematic steps were taken to ensure thoroughness and accuracy. Firstly, we defined the research questions to set the direction for the entire review process. Next, we developed a protocol, that is, created a detailed plan outlining the methods and criteria for the review. This included defining inclusion and exclusion criteria, search strategies, and data extraction methods (Lasserson et al., 2021). For this study, the inclusion criteria were all resources related to the objectives of the study. Then we conducted a literature search, that is, performed a search of relevant databases and sources to identify studies that meet the inclusion criteria. We used academic databases such as PubMed, Scopus, Google Scholar and institutional reports

published. Next step, we screened and selected studies by reviewing the titles and abstracts of the identified studies to determine their relevance. Full-text screening was then conducted to confirm eligibility based on the predefined criteria.

Later, we systematically extracted relevant data from the included studies. This involves recording key information such as study design, sample size, interventions, outcomes, and results. We also evaluated the quality and risk of bias using appropriate tools and checklists. This step ensured the reliability and validity of the findings. Next, we analyzed and synthesized the data from the included studies using qualitative synthesis. Qualitative synthesis is a method used to combine results from multiple qualitative studies. It aims to generate new insights and understandings by integrating findings from different contexts and perspectives (Barnett-Page & Thomas, 2009). We then wrote a comprehensive report detailing the methods, findings, and conclusions of the review.

The report followed the guidelines for transparency and reproducibility to ensure that the research process is clear, replicable, and trustworthy. Finally, we periodically updated the review to incorporate new evidence and maintain its relevance (Lasserson et al., 2021). The time frame of this comprehensive review was from July 2024 to February 2025. The methodology enabled an examination of the current state of AI-driven VLEs in AHEIs identifying the current state, benefits and challenges for future development (see Figure 1).

The quality of included studies was assessed using the GRADE approach, which evaluates factors such as study limitations, consistency of results, directness of evidence, precision of estimates, and risk of publication bias. This method ensured a thorough evaluation of the reliability and validity of the findings. Additionally, the quality assessment considered the study design, sample size, interventions, outcomes, and results, using tools specific to certain study designs to identify potential flaws in methods or implementation. Lastly, the risk of bias evaluation was conducted using appropriate checklists and tools, ensuring that the findings were reliable and valid by minimizing the impact of biases on the overall conclusions (Cochrane, 2025). These systematic steps provided a robust framework for assessing the quality of the included studies, enhancing the credibility and reliability of the review's findings.

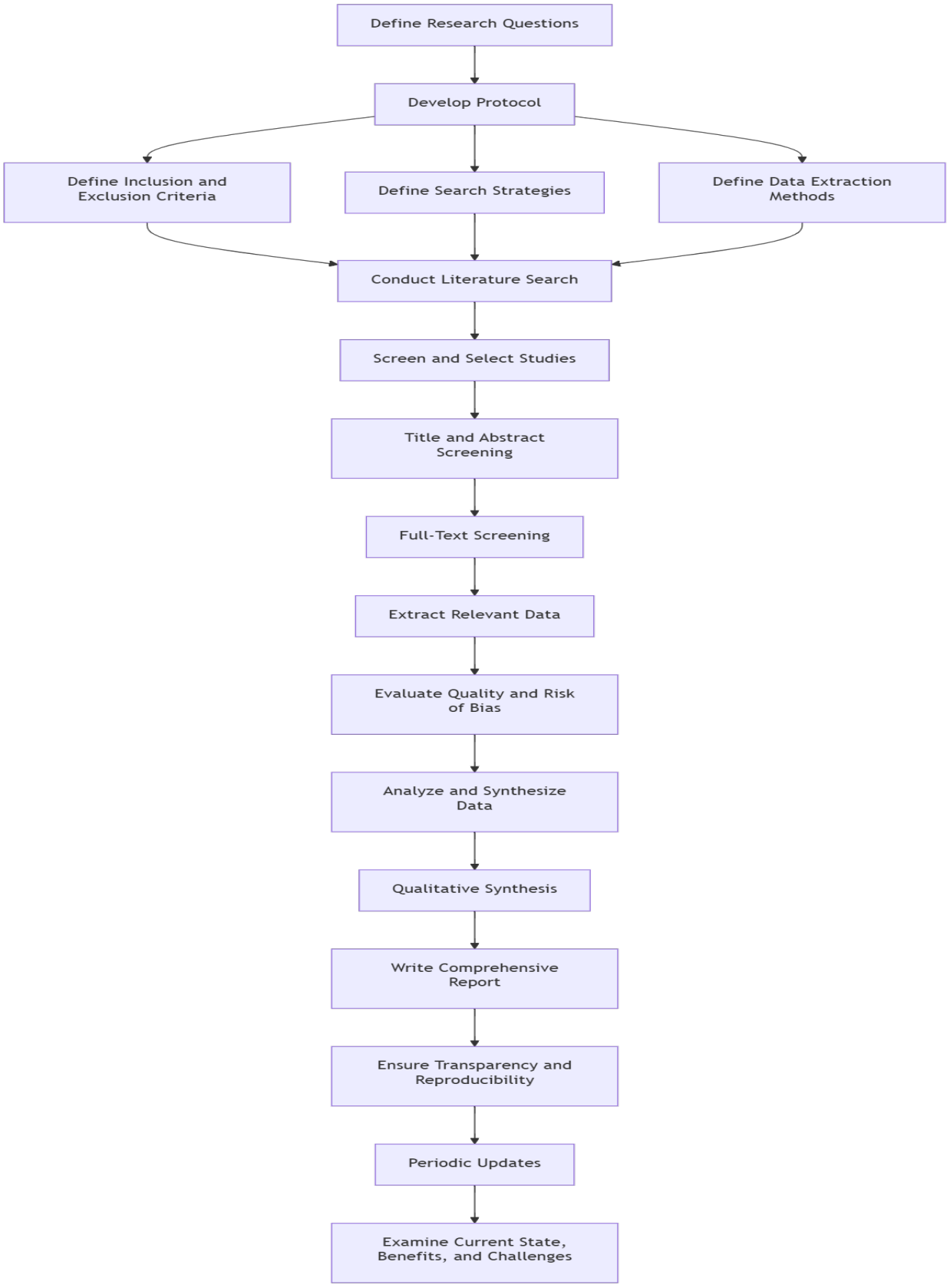

Figure 1: Flow diagram of study selection process

Findings and discussion

In examining the potential of AI-driven VLEs in AHEI, the findings and discussion section is pivotal. This section will delve into the empirical evidence and theoretical insights gathered during the study, providing a comprehensive analysis of how AI technologies are being integrated into educational systems across the continent. The findings will highlight the themes that emerged from the review which are the current state, potential benefits, and challenges associated with the adoption of AI-driven VLEs.

The current state of AI-driven VLEs in African higher education

The advent of AI-driven VLEs in African higher education has been met with enthusiasm, with several institutions adopting this innovation. The findings of the current state of AI-driven VLEs in African higher education is discussed based on case studies from various higher education institutions in Africa.

A case study at Mohammed VI Polytechnic University in Morocco is one such example (Baba et al., 2024). The study evaluated the effect of an AI-driven personalised educational platform on students' academic achievement and educational progress. The platform, designed for mobile devices, allowed instructors to easily upload information, and learners could interact with an AI mentor through a chat interface seamlessly integrated into their mobile course materials. This study compared two groups of students. One group had access to a mobile personalised learning platform powered by AI, whereas the control group did not have access to it. A comparative analysis of mobile educational experiences, levels of engagement, and academic outcomes across these groups was done. In addition, qualitative feedback was gathered from educators and students to evaluate the mobile usability and effectiveness of the system. The results of the study demonstrate that the AI-driven mobile-tailored learning system significantly improves the experience of mobile learners. The increased levels of engagement, improved understanding, and superior academic achievements support this claim. This study not only supports the potential of AI-driven personalised mobile learning in higher education but also emphasizes the importance of continuous innovation to improve its usefulness and effectiveness.

The adoption of AI-driven VLEs in African higher education is not limited to Morocco. In South Africa, the University of the Witwatersrand has implemented an AI-powered virtual learning platform that uses machine learning algorithms to personalize learning for students (University of the Witwatersrand, 2023). The platform has been shown to improve student engagement and academic performance, particularly among historically disadvantaged students.

In Ghana, institutions are also making strides in integrating AI-driven VLEs. For example, the Kwame Nkrumah University of Science and Technology (KNUST) has implemented AI-powered tools for scheduling and classroom management, which help streamline administrative tasks and enhance the learning experience (Knowledge Innovations, 2024). Additionally, platforms like eLearnAfrica have been pivotal in providing personalised lessons and real-time feedback, particularly during the pandemic, ensuring continuity in education (Knowledge Innovations, 2024). Also, The African Institute for Mathematical Sciences (AIMS) in Ghana has integrated AI tools to enhance their educational offerings. These tools provide personalised learning experiences and real-time feedback, particularly in STEM

subjects, helping to improve student outcomes (Knowledge Innovations, 2024). Additionally, Accra Technical University (ATU) is exploring the use of AI labs to support innovative learning. These labs facilitate real-time collaboration and hands-on learning experiences, preparing students for the demands of the Fourth Industrial Revolution (The Ghana Report, 2025). See Table 4 for clarification.

The adoption of AI-driven VLEs in African higher education shows promising results, particularly in enhancing engagement, academic performance, and personalised learning. Comparing these findings with studies from other regions reveals both similarities and differences in implementation, challenges, and outcomes.

African case studies, such as those from Mohammed VI Polytechnic University (Morocco) and the University of the Witwatersrand (South Africa), demonstrate that AI-driven VLEs significantly improve student engagement and academic performance (Baba et al., 2024; University of the Witwatersrand, 2023). Similar trends are observed in Western contexts, where AI-powered platforms like Carnegie Learning's intelligent tutoring systems in the Hamad Bin Khalifa University in Qatar, Munster Technological University in Ireland, Queen Mary University of London in the UK, Princess Sumaya University for Technology in Jordan, University of Houston in the USA, Alfaisal University in Saudi Arabia, and Chicago State University in the USA have led to measurable improvements in student outcomes, particularly in Science, Technology, Engineering, and Mathematics (STEM) subjects (Ahmad et al.,2024).

In addition, a study conducted at Universidad Europea de Madrid, in Spain focused on improving inclusive learning using an AI-powered chatbot designed to assist university students. The chatbot demonstrated high proficiency, with positive evaluations from students regarding usability, accuracy, interaction, and utility (Ruiz Lázaro et al., 2024).

In Vietnam, a study at Ho Chi Minh City University of Technology and Education (HCMUTE) evaluated the integration of ChatGPT into teaching and learning dynamics. The AI tool was found to enhance student learning behaviors and academic tasks, although concerns about overreliance and academic dishonesty were noted (Nguyen et al., 2024)

In all, AI-driven VLEs have the potential to significantly improve student outcomes in African higher education. The case studies from Morocco, South Africa and Ghana demonstrate the effectiveness of these innovations in enhancing engagement, understanding, and academic performance. Comparisons with other regions highlight similar positive impacts, although challenges such as overreliance and academic dishonesty persist. Continuous innovation and standardized evaluation frameworks are essential to maximize the benefits of AI in education.

Table 4: Current state of AI-driven VLEs in African higher education based on case studies in study

Institution	Country	AI-Driven VLE Implementation	Outcomes
Mohammed VI Polytechnic University	Morocco	AI-driven personalised educational platform for mobile devices	Improved engagement, understanding, and academic achievement
University of the Witwatersrand	South Africa	AI-powered virtual learning platform using machine learning algorithms	Enhanced student engagement and academic performance, particularly among historically disadvantaged students
Kwame Nkrumah University of Science and Technology (KNUST)	Ghana	AI-powered tools for scheduling and classroom management	Streamlined administrative tasks and enhanced learning experience
eLearnAfrica	Ghana	Personalised lessons and real-time feedback	Ensured continuity in education during the pandemic
African Institute for Mathematical Sciences (AIMS)	Ghana	AI tools for personalised learning experiences and real-time feedback in STEM subjects	Improved student outcomes
Accra Technical University (ATU)	Ghana	AI labs for innovative learning and real-time collaboration	Prepared students for the Fourth Industrial Revolution

Potential benefits of AI driven VLE in AHEI

The potential benefits of AI-driven VLEs in African higher education are numerous and significant (Table 5). One of the primary benefits is the ability to increase access to education, particularly in regions where traditional brick-and-mortar institutions are scarce or inaccessible (UNESCO, 2019). AI-driven VLEs can provide high-quality educational content and resources to students across the continent, helping to bridge the educational gap and promote inclusivity (Sey & Mudongo, 2021).

Another benefit is the personalization of learning experiences and educational content, which can be tailored to individual students' needs and abilities (Dziuban et al., 2018). AI can help identify learning gaps and provide targeted interventions, ensuring that students receive the support they need to succeed (Crompton et al., 2024). AI can have Intelligent Tutoring Systems (ITS) which provide personalised instruction and feedback, simulating one-on-one tutoring to improve student understanding and retention (VanLehn, 2011). This approach has been shown to improve student engagement and academic performance (Luckin et al., 2024).

AI algorithms can analyze student data and adapt the learning environment to optimize student outcomes, leading to improved academic performance and increased student engagement (Crompton et al., 2024). It is worth noting that AI can also analyze student data to predict academic performance and identify at-risk students, enabling early interventions to improve student outcomes (Arnold & Pistilli, 2012). AI has improved the accessibility of learning materials in that AI technologies, such as speech recognition and text-to-speech, has supported students with disabilities, making learning materials more accessible and inclusive (Arias-Flores et al., 2025). For instructors, AI-driven VLEs have provided real-time feedback and assessment, freeing them to focus on more complex and creative tasks (Wang et al., 2020). AI can automate administrative tasks such as scheduling, grading, and feedback, reducing the workload on instructors and allowing them to focus more on teaching (Balfour, 2013).

AI-driven VLEs accommodate many students, making it easier to scale educational programs and reach a broader audience, particularly in regions with limited access to traditional educational resources (Knowledge Innovations, 2024). Furthermore, AI-driven VLEs facilitate collaboration and knowledge sharing among students and educators across Africa, promoting a sense of community and fostering a culture of innovation and entrepreneurship (Holmes & Porayska-Pomsta, 2023).

The benefits of AI-driven VLEs in African higher education align with findings from other regions, though contextual differences influence adoption and effectiveness. In Africa, AI-driven VLEs help bridge gaps in regions with limited physical institutions (UNESCO, 2019). AI-enhanced online learning has expanded access to education in rural areas of Latin America. The transformative impact of AI in personalizing learning experiences, supporting teachers and students, and optimizing educational management, particularly in under-resourced regions have been revealed (World Bank, 2024). However, Africa faces unique infrastructural challenges, such as inconsistent internet connectivity and electricity, which are less pronounced in developed regions (Sey & Mudongo, 2021).

Moreso, AI-driven personalization in Africa mirrors trends in the U.S. and Europe, where adaptive learning improves student outcomes (Dziuban et al., 2018; VanLehn, 2011). However, while Luckin et al., (2024) discusses various aspects of AI integration in education in the Western institutions, African institutions may face various challenges in integrating AI due to financial limitations that lead to the adoption of less advanced technological solutions (Crompton et al., 2024).

While AI-driven VLEs offer comparable benefits globally, Africa’s adoption is hindered by infrastructural, financial, and training gaps. Successful models from Global North can be adapted, but localized solutions are essential for sustainable

implementation.

Table 5: Summary of potential benefits of AI driven VLE in AHEI

Theme	Benefits
Increased Access to Education	- Geographical Reach: Provides high-quality educational content to students in remote or underserved regions. - Inclusivity: Helps bridge the educational gap and promote inclusivity across the continent.
Personalised Learning Experiences	- Tailored Content: Customizes educational content to individual students' needs and abilities. - Targeted Interventions: Identifies learning gaps and provides personalised support through Intelligent Tutoring Systems (ITS).
Improved Student Outcomes	- Optimized Learning: Analyzes student data to adapt the learning environment for better academic performance and engagement. - Early Interventions: Predicts academic performance and identifies at-risk students for timely support.
Enhanced Accessibility	- Support for Disabilities: Utilizes AI technologies like speech recognition and text-to-speech to make learning materials more accessible.
Support for Instructors	- Real-Time Feedback: Provides immediate feedback and assessment, allowing instructors to focus on complex and creative tasks. - Administrative Automation: Automates tasks such as scheduling, grading, and feedback, reducing instructors' workload.
Scalability and Collaboration	- Large-Scale Education: Accommodates a large number of students, making it easier to scale educational programs. - Community Building: Facilitates collaboration and knowledge sharing among students and educators, fostering a culture of innovation and entrepreneurship.

Challenges associated with AI VLEs in AHEI

The adoption of AI-driven VLEs in African higher education has been met with enthusiasm but also raises concerns about the challenges and limitations of this technology (Table 6). One of the challenges is the issue of access to reliable internet connectivity, which is a prerequisite for virtual learning (Sey & Mudongo, 2021). Many African countries still struggle with poor internet penetration, making it difficult for students to access VLEs (Internet World Stats, 2020). There is often a disparity in access to necessary technology and internet connectivity, which can exacerbate the digital literacy gap. Students from lower socioeconomic backgrounds may have less exposure to digital technologies, further hindering their ability to engage with AI-driven VLEs (Abrams, 2025). Many AHEI face challenges related to inadequate infrastructure, including limited access to high-speed internet and modern computing facilities. These limitations hinder the effective implementation of AI-driven VLEs (Ragolane & Patel, 2024).

Another challenge is the lack of digital literacy among many students and educators, which can hinder the effective use of AI-driven VLEs (Crompton, 2017). Understanding how AI works and how to leverage AI tools for educational purposes

is crucial. AI-driven VLEs often require more advanced digital skills, including the ability to interact with AI tools, understand data analytics, and use various digital resources effectively (Joseph et al., 2022). Knowing how to use AI for personalised learning, data analysis, and automated feedback is also essential (Abrams, 2025). Without proper training and ongoing support, both students and educators may struggle to use AI tools effectively, leading to underutilization of the available resources (Joseph et al., 2022). Integrating digital literacy into the curriculum is essential for preparing students and educators to use AI-driven VLEs effectively (Abrams, 2025). Theis is because there is a shortage of skilled AI professionals and educators trained to use AI technologies effectively. This skills gap can impede the adoption and integration of AI in educational settings (Kurien & Soglo, 2024). Educational policies need to support digital literacy initiatives, including funding for technology and professional development for educators.

Additionally, the cost of devices and data plans can be prohibitively expensive for many students, exacerbating existing inequalities in access to education (Holmes & Porayska-Pomsta, 2023). Implementing AI-driven VLEs requires substantial financial investment in technology, infrastructure, and training. Many African institutions operate under tight budgets, making it challenging to allocate sufficient resources for AI initiatives (Kurien & Soglo, 2024).

AI-driven VLEs may not be able to replicate the social and cultural nuances of traditional classroom learning, potentially leading to a sense of isolation and disconnection among students (Palos, 2023). Also, in some regions, there may be cultural attitudes that undervalue digital literacy or prioritize traditional learning methods over digital ones. Some educators and students may be resistant to adopting new technologies due to a lack of confidence or fear of the unknown (Joseph et al., 2022).

Moreover, there are concerns about the quality of AI-generated content, which may not be tailored to the specific needs and contexts of African students (Dziuban et al., 2018). The lack of African representation in the development of AI-powered educational tools also raises concerns about cultural bias and relevance (Wang et al., 2020). There is also a concern of ensuring the privacy and security of student data. Many institutions lack robust data protection frameworks, which can lead to vulnerabilities and potential misuse of sensitive information (Ifenthaler & Schumacher, 2016; Maina & Kuria, 2024). The reliance on AI-driven VLEs may perpetuate existing power dynamics, with some students having greater access to technology and digital skills than others (Crompton et al., 2021).

Conversely, the integration of AI in education presents several ethical challenges that must be addressed to ensure responsible use. One major concern is algorithmic bias, where AI systems may perpetuate existing inequalities due to biased training data. This can lead to unfair treatment of students from marginalized groups (Dwivedi et al., 2023). Another issue is the potential replacement of human educators. While AI can enhance educational experiences, it should complement rather than replace human teachers to preserve the essential human elements of empathy and mentorship in education (Gašević et al., 2023).

Data privacy and security are critical in this digital age, especially with the rise of AI in education. Key concerns include data breaches, which can lead to identity theft and financial loss, and inadequate data protection, making systems

vulnerable to attacks. Privacy risks arise from the extensive collection of personal data, often leaving users feeling they lack control. AI systems often require vast amounts of student data, raising questions about how this data is collected, stored, and used. Ensuring robust data protection measures and transparent data governance policies is essential to safeguard student privacy (Chen, 2024). Also, the accountability of AI systems must be considered. Clear guidelines and ethical frameworks are needed to hold AI developers and educational institutions accountable for the impact of AI technologies (Teachers Guide, 2025).

The challenges associated with AI-driven VLEs in AHEI share similarities with those in other regions but also exhibit distinct differences due to socioeconomic, infrastructural, and cultural factors. In Africa, unreliable internet connectivity and inadequate digital infrastructure are major barriers to AI-driven VLE adoption (Sey & Mudongo, 2021; Ragolane & Patel, 2024). Similar challenges exist in other developing regions, such as South Asia and Latin America, where rural and underserved areas face limited internet penetration (UNESCO, 2023). However, developed regions like North America and Europe generally have better infrastructure, though rural areas in these regions still experience connectivity gaps (National Institute of Standards and Technology [NIST], 2019).

In addition, African institutions struggle with low digital literacy among students and educators (Crompton, 2017; Joseph et al., 2022). In contrast, Western countries tend to have higher baseline digital literacy, though disparities persist among marginalized groups. There is therefore the need for inclusive digital skills policies that address these inequalities and support lifelong learning for all adults (Eynon, 2021).

Table 6: Summary of challenges associated with AI driven VLEs in AHEI

Theme	Challenges
Access to Technology and Internet	- Poor internet penetration in many African countries - Disparity in access to necessary technology and internet connectivity - Inadequate infrastructure, including limited access to high-speed internet and modern computing facilities
Digital Literacy	- Lack of digital literacy among students and educators - Need for advanced digital skills to interact with AI tools and use digital resources effectively - Shortage of skilled AI professionals and educators trained to use AI technologies
Financial Constraints	- High cost of devices and data plans - Substantial financial investment required for technology, infrastructure and training - Tight budgets in many African institutions
Social and Cultural Barriers	- Difficulty replicating social and cultural nuances of traditional classroom learning - Resistance to adopting new technologies due to lack of confidence or fear of the unknown - Cultural attitudes that undervalue digital literacy or prioritize traditional learning methods
Quality and Relevance of Content	- Concerns about the quality of AI-generated content - Lack of African representation in the development of AI-powered educational tools, raising concerns about cultural bias and relevance
Privacy and Security	- Ensuring the privacy and security of students - Lack of robust data protection frameworks
Ethical and Regulatory Issues	- Potential for AI to perpetuate existing power dynamics - Ethical issues such as bias in AI algorithms and the potential for AI to replace human educators - Absence of comprehensive regulatory frameworks and policies governing the use of AI in education

Addressing Challenges in AI-Driven VLEs in AHEI

To address the challenges associated with AI-driven VLEs in African higher education, several strategies can be implemented. Improving internet connectivity is crucial; governments and private sectors should invest in infrastructure to ensure reliable and affordable internet access (Queiros & de Villiers, 2016). Bridging the digital literacy gap requires integrating digital skills into the curriculum and providing ongoing training for both students and educators

(Joseph, 2025), as well as improving technological literacy through digital literacy initiatives (Setyanugraha & Wahyuni, 2024). This can be supported by educational policies that fund technology and professional development.

Addressing socioeconomic disparities involves providing subsidized devices and data plans to students from lower-income backgrounds. There is a significant digital divide and varying access to internet and mobile networks in low-income countries. Therefore, dedicated teachers, resilient educators, and the right EdTech tools are needed to support education (Jordan et al., 2021). Governments and development organizations should prioritize funding for EdTech in underserved schools to promote equity. Enhancing infrastructure by upgrading computing facilities and ensuring access to high-speed internet is essential for the effective implementation of AI-driven VLEs (Ade-Ibijola & Okonkwo, 2023).

To tackle the lack of digital literacy, comprehensive training programs should be established to help educators and students understand and leverage AI tools effectively (Burke & Crompton, 2024). Promoting cultural acceptance of digital literacy through awareness campaigns can help overcome resistance to new technologies. Ensuring the quality and relevance of AI-generated content involves including African representation in the development of educational tools to avoid cultural bias.

In addition, addressing ethical concerns is essential for the responsible deployment of AI technologies, especially in Africa. The lack of comprehensive regulatory frameworks and policies governing AI in education can create uncertainties and hinder the widespread adoption of AI-driven VLEs) (Maina & Kuria, 2024). To address these concerns, it is necessary to reduce bias by using diverse datasets and conducting regular audits to ensure fairness, accuracy, and inclusiveness in AI-driven educational tools. Ensuring transparency through explainable AI and human override options is also important to build trust, enhance understanding, and ensure ethical decision-making.

Conversely, defining clear accountability for AI decisions and maintaining human oversight should be prioritized to ensure responsible use, mitigate risks, and uphold societal values. Protecting privacy with strict data laws such as General Data Protection Regulation (GDPR) and anonymizing student data is crucial to safeguarding students' personal information, ensuring compliance with legal standards, and maintaining trust in educational institutions. Promoting equity by providing equal access to AI tools and funding edtech in underserved schools by the government and other development organizations is essential to ensure that all students, regardless of their socioeconomic background, can benefit from advanced educational technologies. Using AI to assist, not replace, teachers, thereby preserving empathy and mentorship in education, should be encouraged to develop the educational experience while preserving the essential human elements.

Moreso, designing AI to foster student autonomy, choice, and critical thinking is vital to enhance the overall learning experience and prepare students for the complexities of the modern world. By promoting these skills, AI-driven educational tools can help students become more independent learners, make informed decisions, and develop the ability to analyze and solve problems critically. This approach not only improves academic outcomes but also equips students with essential skills for their future careers and personal growth. Finally, fostering

collaboration among educators, developers, and policymakers is necessary for effective policy and dialogue to create and implement effective policies and strategies that ensure the successful integration of AI in education (see Table 7).

Table 7: Summary of strategies to address challenges associated with AI driven VLEs in AHEI

Challenges	Strategies for AHEI
Internet Connectivity	Invest in infrastructure to ensure reliable and affordable internet access
Digital Literacy	Integrate digital skills into the curriculum and provide ongoing training for students and educators
Socioeconomic Disparities	Provide subsidized devices and data plans to students from lower-income backgrounds
Infrastructure	Upgrade computing facilities and ensure access to high-speed internet
Ethical Concerns	Reduce bias by using diverse datasets and conducting regular audits; ensure transparency through explainable AI and human override options
Privacy	Protect privacy with strict data laws like GDPR and anonymize student data
Equity	Provide equal access to AI tools and fund EdTech in underserved schools
Teacher Support	Use AI to assist, not replace, teachers to preserve empathy and mentorship
Student Autonomy	Design AI to foster student autonomy, choice, and critical thinking
Collaboration	Foster collaboration among educators, developers, and policymakers for effective policy and dialogue

It is worth noting that implementing AI-driven VLEs in AHEI can lead to potential unintended consequences. Bias and discrimination may arise as AI systems can amplify existing biases in training data, resulting in unfair treatment of marginalized groups (Marr, 2023). Privacy concerns are significant due to the extensive collection and analysis of personal data, which could be misused or inadequately protected (NAIAC, 2023). In addition, the digital divide might worsen, as students with limited internet access or digital literacy skills could struggle to benefit from these technologies, increasing educational inequality (NAIAC, 2023). Job displacement is another risk, with AI potentially automating educational tasks and displacing educators and administrative staff, necessitating retraining efforts (Gašević et al., 2023). Ethical dilemmas arise regarding the transparency and accountability of AI decision-making processes, requiring

alignment with ethical standards to avoid negative societal impacts (Chen, 2024). Lastly, cultural relevance is a concern, as AI-driven VLEs developed in different cultural contexts may not be fully applicable to African settings, potentially alienating students and educators (NAIAC, 2023).

Limitations

The comprehensive literature review used in this study has several limitations. The selection process for studies can introduce bias if the criteria are not clearly defined or consistently applied (Haddaway, 2020). There is a tendency to include only published studies, potentially overlooking relevant unpublished or grey literature (Rahman, 2020). Additionally, the quality of included studies can vary significantly, impacting the reliability of the synthesis (Haddaway, 2020). Evaluating the quality of each study requires careful and consistent assessment, which can be challenging (Rahman, 2020).

Conclusion

The future of AI-driven VLEs in African higher education is promising, with potential to revolutionize the way students learn, and teachers teach. AI-driven VLEs are being enthusiastically adopted in AHEI, significantly improving student engagement, understanding, and academic performance. Case studies from Morocco, South Africa and Ghana highlight the transformative potential of these technologies in advancing education across the continent.

The key points from this discussion highlight the benefits of AI-driven VLEs. AI-driven VLEs in African higher education significantly increase access to quality education, particularly in underserved regions, by providing high-quality content and resources. They personalize learning experiences, improve student engagement and academic performance, and support students with disabilities. Additionally, these environments facilitate collaboration and knowledge sharing, helping to foster a culture of innovation and entrepreneurship across the continent.

However, this adoption faces challenges, including unreliable internet connectivity, digital literacy gaps, high costs, and inadequate infrastructure. Additionally, concerns about cultural relevance, data privacy, and ethical issues such as bias in AI algorithms and the potential replacement of human educators need to be addressed. Overcoming these challenges is essential to ensure equitable and inclusive access to quality education across the continent.

Recommendations and future research directions

To fully harness the benefits of this technology, several directions and recommendations must be considered. Policymakers should allocate funds to enhance internet connectivity and technological infrastructure in educational institutions, ensuring equitable access to AI-driven VLEs. They need to establish clear guidelines and policies for the ethical use of AI, focusing on data privacy, security, and bias mitigation. Supporting research initiatives to develop context-specific AI solutions tailored to African students' needs is crucial. Additionally, facilitating partnerships between educational institutions, industry experts, and international organizations will help share the best practices and drive innovation in AI-driven education.

Educators should enhance digital literacy by participating in training programs to improve their skills and effectively integrate AI tools into the curriculum. They should adopt AI-driven VLEs to create personalised learning experiences tailored to individual student needs and learning styles. Maintaining academic integrity is crucial, ensuring the quality and relevance of AI-generated content by adhering to established standards and continuously monitoring effectiveness. Also, educators should use AI to develop interactive and engaging learning activities that promote critical thinking and collaboration among students.

Lastly, institutions should offer comprehensive training programs for faculty and staff to ensure effective use of AI tools. Establishing an AI governance body is essential to oversee implementation, address ethical concerns, and ensure regulatory compliance. Ensuring equity of access involves providing all students and staff with equal access to AI tools and resources, addressing any disparities. Furthermore, institutions should develop robust quality assurance frameworks to continuously monitor and improve the effectiveness of AI-driven VLEs. These measures will help maximize the benefits of AI in education and ensure its responsible and equitable use.

To fully harness the benefits of AI-driven VLEs in AHEIs, future research should focus on these key areas:

1. Assess the current digital infrastructure in AHEIs and identify needs for upgrading internet connectivity and technological resources. Research should explore cost-effective and sustainable models to bridge the digital divide.
2. Develop and evaluate AI-driven VLEs tailored to the unique cultural, linguistic, and educational contexts of African students. This includes creating AI algorithms that reflect Afrocentric perspectives and address specific challenges in African higher education.
3. Examine the effectiveness of digital literacy programs for educators and students. Research should identify the most effective training methods and tools to enhance digital skills and ensure successful AI integration in the classroom.

The implications for practice are significant, as government, educational institutions and policymakers must prioritize infrastructure development, digital literacy training, and quality assurance frameworks to ensure effective integration and utilization of AI-driven VLEs. Future research should also explore the ethical implications of AI-driven VLEs, including issues related to data privacy, algorithmic bias, and the digital divide.

This study contributes to the field of AI-driven VLEs in African higher education by providing empirical evidence of their positive effect on student engagement, understanding, and academic performance. It highlights the transformative potential of these technologies through case studies from various African institutions, demonstrating their effectiveness in increasing access to quality education and personalizing learning experiences. Additionally, the study underscores the potential benefits, and the challenges associated with the adoption of AI in AHEI, offering valuable insights for policymakers, educators, and researchers.

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