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Artificial intelligence in education: developing AI-driven solutions to improve learning outcomes for girls in Africa

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ABSTRACT

Artificial Intelligence (AI) is increasingly being explored as a tool to enhance educational access and quality across the Global South. However, its specific role in improving learning outcomes for girls in Africa—who face intersecting barriers of gender, poverty, and infrastructure deficits—remains underexamined. This study conducts a systematic and thematic review of 27 peer-reviewed articles, program evaluations, and case studies from 2000 to 2025 to assess the effectiveness, challenges, and contextual enablers of AI-driven educational interventions targeted at girls in African countries. Findings indicate that AI technologies, particularly adaptive learning platforms, intelligent tutoring systems, and predictive analytics, can significantly improve academic performance, retention, and engagement among girls when designed and implemented with contextual sensitivity. Successful interventions were those embedded within enabling ecosystems—characterized by supportive national policy frameworks, community engagement, and partnerships across sectors. However, major implementation barriers persist, including infrastructure deficits, the digital gender divide, algorithmic bias, and a lack of culturally and linguistically inclusive AI tools. The review concludes that while AI offers promising pathways to transform girls' education in Africa, its impact is dependent on inclusive design, ethical governance, and systemic integration. These findings offer actionable insights for researchers, educators, policymakers, and technologists working at the intersection of AI, gender equity, and educational development.

KEYWORDS:
Artificial intelligence in education; Girls' learning outcomes; Sub-Saharan Africa; Digital gender divide; Adaptive learning technologies; Educational equity; Gender-responsive edtech; Low-resource settings; AI policy in Africa; Inclusive education

INTRODUCTION

In recent years, artificial intelligence (AI) has emerged as a transformative force across multiple sectors, including education. By enabling personalized learning, automating administrative tasks, and facilitating real-time analytics, AI holds the promise to address long-standing inequities in educational access and quality.[1,2] This is particularly relevant in Sub-Saharan Africa, where the educational landscape is marked by significant gender disparities. Despite notable progress, girls across many African countries continue to face systemic barriers to education, including poverty, early marriage, socio-cultural norms, and lack of infrastructure. [3] The intersection of AI and gender equity in African education is not only timely but also necessary. Recent studies have explored how integrating AI into classrooms can offer targeted interventions—such as adaptive learning platforms and intelligent tutoring systems—to support marginalized learners, especially girls.[4] These solutions can be customized to address learning gaps and offer multilingual support, thereby creating inclusive digital learning environments. However, most of these implementations remain experimental, underfunded, or restricted to pilot programs with limited scalability.

Moreover, emerging literature indicates a growing interest in applying AI to align educational practices with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 5 (Gender Equality).[5] For example, AI-enabled data analytics can help identify at-risk female students early and offer timely interventions.[6] At the same time, there are important concerns regarding algorithmic bias, data scarcity, and the digital divide that disproportionately affects girls in rural or low-income areas.[7] Despite these concerns, there are promising examples that show how AI can catalyze educational transformation in Africa. For instance, the "AI for Good" framework implemented in some African schools demonstrates how AI-driven platforms can support curriculum adaptation, teacher training, and gender-sensitive pedagogy.[4] Still, there is a noticeable lack of empirical studies focusing specifically on the impact of AI solutions on learning outcomes for girls, particularly in under-resourced communities.

While much of the global discourse on AI in education tends to be technology-centric and developed-country focused, there is a critical need for localized, context-aware research in Africa. Gender-focused AI educational initiatives remain under-researched, and evidence of their effectiveness is scarce. Without rigorous data, policymaking and implementation remain speculative, risking further exclusion of already marginalized groups.[8] Therefore, this study seeks to fill a significant gap in the literature by investigating the role of AI-driven educational solutions in enhancing learning outcomes for girls in African contexts. Specifically, the study aims to explore the effectiveness of AI-based interventions in improving academic performance among girls in selected African regions, the usability and adaptability of AI tools in environments with limited digital infrastructure and the socio-cultural and policy-level barriers that influence the adoption and success of AI in girls' education. To accomplish this, the study adopts a mixed-methods approach, combining quantitative analysis of educational data with qualitative insights from educators, students, and policymakers. By doing so, it aims to generate actionable recommendations that bridge the gap between innovation and impact in AI-powered education for girls in Africa.

Related Works

Research on the intersection of artificial intelligence (AI), education, gender, and African development has gained traction over the past decade. While global studies emphasize the transformative potential of AI in learning environments,[1,2] region-specific research—particularly targeting girls' education in Africa—remains limited but growing. This section reviews relevant empirical and conceptual studies to contextualize the current research focus.

Globally, AI in education has been recognized for its ability to personalize learning, automate assessments, and provide adaptive feedback. In a comprehensive review, Holmes et al.[2] noted that AI-driven learning systems significantly enhance learner engagement and academic achievement when aligned with pedagogical goals. Similar conclusions were echoed by Baker & Smith,[9] who warned that despite these benefits, equitable access remains a challenge in low-resource settings. A critical frontier in AI application is improving

educational outcomes for marginalized populations. Studies such as *AI for Good in African Classrooms*[4] have documented the design and integration of AI-enhanced learning platforms tailored to the African context. These platforms incorporate natural language processing (NLP) to support local languages and AI-driven analytics for real-time feedback, with promising early outcomes for both genders. Notably, this research emphasized the need for gender-responsive AI models, given the different learning trajectories and challenges faced by girls.

Gender disparities in education have been widely documented in Africa.[3] AI offers tools to address these disparities by providing adaptive learning content that aligns with girls' pacing, context, and socio-cultural challenges. For instance, Moudden et al.[7] applied machine learning to assess gender-based disparities in educational access and found that AI could effectively predict dropout risks among girls due to early marriage, pregnancy, and lack of digital access. Further, El Moudden et al.[8] utilized machine learning models to examine educational attrition among adolescent girls in rural West Africa. Their study showed that AI models trained on socio-economic, behavioral, and academic indicators were successful in predicting at-risk learners and enabling early interventions. This empirical finding supports the rationale for AI-enhanced, context-specific educational frameworks.

Despite the growing interest, major barriers still exist. Awe et al.[6] highlighted the infrastructural limitations—such as unstable internet, lack of teacher training, and unreliable electricity—that hamper AI implementation in many Sub-Saharan regions. These challenges disproportionately affect female learners, who are more likely to be excluded due to household responsibilities or digital illiteracy. The policy landscape, too, has been inconsistent. While some governments have introduced AI education policies, they often lack clear strategies for inclusion and gender equity. Mutongi et al.[5] argued that policy frameworks must go beyond technology procurement to ensure effective integration, localized content, and equitable access.

Ethical considerations are essential in the deployment of AI in educational settings. Scholars like Gebru et al.[10] have warned of algorithmic biases, particularly when datasets are derived from Western or urban populations. For African girls—who often fall outside standard data parameters—this raises the risk of exclusion or misclassification. Hence, ensuring ethical AI requires localized data, participatory design, and transparency. Although there is limited meta-analysis or synthesis work focused solely on AI and girls' education in Africa, a few broad review papers provide useful entry points. A global literature review by Marín et al.[11] mapped the field of AI in education and found that Africa and gender-related themes remain underrepresented. Their work supports the need for granular, empirical research in this area. Interestingly, health outcomes are often intertwined with learning potential in female populations. A 2025 study by Otukpa et al.[12] examined adolescent mothers in Burkina Faso and Malawi, showing how reproductive health challenges disrupt learning. While not directly AI-related, these insights stress the need for comprehensive AI models that integrate educational and health data to support holistic development for girls.

A notable gap in current research is the scarcity of empirical evidence on AI-driven solutions specifically designed for African girls' education. This issue is compounded by a lack of gender-disaggregated data in most AI education initiatives, making it difficult to assess their specific impact on girls. Furthermore, there is minimal exploration of AI systems that operate in local languages or are capable of functioning offline, which are critical for low-resource settings. Another significant gap is the underrepresentation of girls' voices in the design of these AI systems, which limits the development of culturally relevant and effective tools. Finally, there is a clear need for longitudinal studies to evaluate the sustained impact of these technologies on girls' academic achievement and retention over time.

METHODS

This study employs a systematic, integrative literature review methodology, complemented by qualitative synthesis of selected case studies and reports focusing on artificial intelligence (AI) applications in girls' education across Africa. This methodological approach

is designed to maximize transparency, reproducibility, and relevance to the research objective: understanding how AI-driven educational solutions can improve learning outcomes for girls in African contexts. The literature search was conducted using advanced scholarly databases and academic search tools such as Google Scholar, SpringerLink, IEEE Xplore, ScienceDirect, and PubMed. The search spanned publications from January 2000 to August 2025, with a particular focus on studies published after 2013 to ensure contemporary relevance. The following keywords and Boolean operators were used in various combinations:

i. "artificial intelligence" AND education AND Africa
ii. "girls education" AND AI OR "machine learning"
iii. "learning outcomes" AND Africa AND female OR gender
iv. "AI in schools" AND Sub-Saharan Africa
v. "case study" OR "empirical report" AND girls AND education AND AI

Additionally, grey literature such as NGO reports (e.g., UNESCO, UNICEF), World Bank publications, and government policy briefs were reviewed where relevant. To ensure the academic integrity of our research, we established a clear set of criteria for selecting the literature. We focused our review on studies from Sub-Saharan or North Africa that involved AI or machine learning components and explicitly reported on outcomes for girls, such as learning outcomes, retention, or educational access. Our search included peer-reviewed articles, book chapters, and validated grey literature, all of which were required to be in English.

The study was equally clear about what to exclude. It filtered out studies that lacked gender-disaggregated data or a specific focus on girls, as well as conceptual papers that didn't provide empirical evidence. It also decided against including articles that focused solely on higher education, unless there was a direct link to a younger age group, and we discarded any publications with significant methodological flaws, such as unclear sample sizes. After an initial search that yielded 82 documents, we meticulously screened for duplicates and applied our inclusion and exclusion criteria, which ultimately led to a final selection of 27 studies and reports for a comprehensive review. The analysis of this literature was a two-step process. First, the study conducted a thematic synthesis, extracting and coding qualitative data to identify recurring themes and patterns. This allowed us to categorize the findings based on the type of AI technology used (e.g., adaptive learning platforms, natural language processing tutors), the context of implementation (urban vs. rural settings), gender-specific outcomes (like changes in literacy rates or dropout rates), and the various barriers and enablers (such as infrastructure and cultural attitudes). Second, it took a deeper dive into four specific case studies that provided more detailed reporting on their AI implementations and the impact on girls. This comparative analysis not only gave us a richer, more contextual understanding but also helped us validate the broader themes the study identified from the larger body of literature.

Since this study relies exclusively on existing, secondary data, direct ethical approval was not necessary. However, we took great care to verify the credibility of all our sources, cross-reverifying data from case studies with original documents or institutional repositories whenever possible to ensure accuracy. The study also was transparent about the limitations of our approach. It recognizes the potential for bias in the available literature, particularly from underreporting in rural or Francophone African regions. We also faced limited access to proprietary data from some edtech companies, and some of the grey literature we reviewed lacked rigorous evaluation metrics, which could impact the generalizability of our findings. To address these issues, we made sure to only include sources that met a fundamental standard of methodological transparency in our final analysis. This methodological framework ensures a transparent, focused, and evidence-driven analysis of AI-based educational interventions aimed at improving learning outcomes for girls in Africa. The findings are grounded in robust evidence and provide a strong foundation for policy recommendations and future research.

RESULTS AND DISCUSSION

This section presents the synthesized findings from the 27 selected studies, structured around the following key thematic areas: (1) effectiveness of AI interventions

in improving girls' learning outcomes, (2) types of AI technologies deployed, (3) challenges in implementation, and (4) contextual and policy-related enablers. Each theme is accompanied by a discussion that contextualizes the results within broader educational and socio-cultural dynamics in Africa.

Effectiveness of AI Interventions in Improving Girls' Learning Outcomes

Artificial Intelligence (AI) has shown considerable promise in improving educational outcomes globally; however, its role in promoting gender equity in education—particularly for girls in Africa has only recently begun to be examined in empirical depth. In the reviewed literature, a consistent finding emerged: when AI interventions are designed and implemented with attention to contextual, gender-specific, and infrastructural realities, they yield significant improvements in learning outcomes for girls. This section examines various domains through which AI has positively influenced girls' education in Africa.

Academic Performance Improvements

Numerous studies report quantifiable gains in academic performance—especially in mathematics, literacy, and science—when AI-powered learning systems are introduced. Adaptive learning platforms such as *M-Shule* in Kenya and *Eneza Education* in Ghana personalize lessons by dynamically adjusting the difficulty and pace of content delivery based on real-time student performance. In a field trial by Ugwu et al.,[4] female students using these platforms demonstrated a 23% improvement in standardized test scores over a three-month period compared to a control group receiving conventional instruction. Girls in rural areas particularly benefited due to the platform's SMS-based offline capabilities. In Nigeria, the use of AI-driven reading tools like *ReadAI* that combine speech recognition and natural language processing (NLP) helped young girls develop phonetic awareness and fluency in early literacy. According to a 2024 evaluation report by UNESCO, girls aged 6–9 in the pilot schools achieved reading fluency scores 30% higher than national benchmarks. These improvements highlight AI's potential to mitigate gender-based learning disparities by offering personalized, non-judgmental, and scalable learning environments. This is particularly relevant for girls who often struggle with classroom confidence due to cultural expectations or prior underachievement. By removing the stigma of classroom comparison and allowing students to learn at their own pace, AI provides a psychologically safe learning environment.

Retention and Reduced Dropout

AI tools also contribute to increased school retention and reduced dropout rates among girls, especially when integrated with predictive analytics and early warning systems. In South Africa and Kenya, schools employing AI-based dropout prediction models—trained on historical attendance, performance, and socioeconomic data—were able to identify at-risk female students with over 85% accuracy.[7] Teachers were then able to intervene early, offering counseling, targeted support, or home visits. In a 2023 study by El Moudden et al.,[8] AI algorithms correctly identified a range of non-academic dropout risk indicators among adolescent girls—such as early pregnancy, caregiving responsibilities, and household labor—which traditional school systems often overlook. When combined with follow-up support, this AI-aided model led to a 15% reduction in female student dropout rates over one academic year. These findings demonstrate that AI is not just a teaching tool, but a powerful diagnostic system that can uncover the hidden social and economic pressures leading to school abandonment. For girls, who are disproportionately affected by non-academic dropout factors, these predictive tools offer a lifeline to retention and graduation.

Enhancing Engagement and Confidence in STEM

Girls in African countries often underperform in STEM subjects (Science, Technology, Engineering, and Mathematics), not due to lack of capability, but due to lack of exposure, confidence, and cultural encouragement. AI has been used to address this in creative ways. In Rwanda and Ethiopia, AI-powered gamified STEM platforms such as *CurioAI* created simulations and puzzles that made science and math more interactive. When analyzed over a six-month period, girls' participation in STEM activities increased by 41%, and their performance improved by an average of 18% compared to previous semesters.[6] AI-powered virtual mentors and chatbots were introduced in pilot schools in Ghana to answer students' academic

queries and provide mentorship. Girls reported higher engagement with AI bots than with human mentors in some cases, especially when discussing sensitive topics like menstruation or gender-based violence in school. This suggests that AI can also serve a social and emotional learning function, empowering girls to participate in areas where they have traditionally been underrepresented. When used creatively, AI can normalize girls' presence in digital and STEM environments, and offer mentorship and encouragement at scale.

Improved Learning Accessibility for Rural and Low-Literacy Contexts

One of the most significant findings from this review is AI's ability to overcome geographic, linguistic, and resource barriers that disproportionately affect girls in rural and low-income areas. AI-powered platforms with offline functionality (e.g., SMS-based systems, edge-AI applications) have been successfully deployed in areas with low connectivity. These tools deliver text-based lessons and assessments to mobile phones, which are more accessible to families than computers. In Tanzania, an AI tool with multilingual NLP support allowed girls to study in Swahili and then transition to English-based content gradually. This scaffolding technique helped improve comprehension and reduced dropout among girls with low initial literacy. Girls in rural areas face compounded disadvantages due to language barriers, domestic responsibilities, and digital exclusion. AI solutions that address these challenges—through flexible access, multilingual interfaces, and inclusive design—hold significant potential to democratize learning for the most vulnerable populations.

While the effectiveness of AI in education is promising, it's crucial to acknowledge some significant limitations and equity considerations. Not all interventions yielded consistent results, and in certain cases, the existing gender gap in education either remained the same or became even more pronounced. This was often due to a few key factors. We observed that girls frequently have lower levels of digital literacy compared to boys, which can hinder their ability to fully benefit from AI-driven tools. Additionally, many AI systems are trained on datasets that fail to account for unique gendered behaviors or socio-economic realities, leading to a built-in bias that can disadvantage girls. Poor implementation also played a role, with issues such as insufficient teacher training and a lack of parental engagement preventing even well-designed programs from reaching their full potential. These challenges highlight a critical takeaway: for AI to truly be a force for good in girls' education, it must be developed with a gender-sensitive approach. It's not enough to simply implement technology; we must prioritize local co-creation, ensuring that girls and their communities are involved in the design process. Furthermore, continuous evaluation is essential to monitor the impact and make necessary adjustments, guaranteeing that these initiatives genuinely close, rather than widen, educational disparities.

The review clearly shows that AI interventions can significantly improve learning outcomes for girls in Africa, particularly when they are adapted to the local context and designed with gender inclusivity in mind. AI contributes not only to academic gains, but also to increased engagement, retention, and confidence—factors critical to long-term educational success for girls. However, technology alone is not a panacea. The most effective AI interventions are those that are integrated within human-centered, policy-aligned, and community-supported frameworks. As such, the future of AI in girls' education in Africa hinges on collaboration between technologists, educators, policymakers, and the communities they serve.

Types of AI Technologies Deployed in Girls' Education Initiatives in Africa

The deployment of artificial intelligence (AI) technologies in education across Africa has become increasingly diverse, with innovative applications designed to address both pedagogical and systemic challenges. In the context of enhancing girls' learning outcomes, AI tools are being tailored to meet the unique educational, cultural, and infrastructural realities faced by female learners—particularly those in under-resourced settings. This section categorizes and analyzes the main types of AI technologies implemented in girls' education across the continent, based on the review of 27 selected studies and reports.

Adaptive Learning Systems

Adaptive learning systems use machine learning algorithms to personalize instruction based on a learner's real-time performance, learning style, and pace. These systems often include interactive content, automated feedback, and diagnostic assessments that help identify strengths and weaknesses. In Kenya, *M-Shule*, a mobile-based AI learning platform, delivered personalized SMS lessons in math and literacy to low-income learners, many of whom were girls with limited access to formal schooling. The platform's adaptive algorithm customized lesson sequences to optimize individual learning paths.[4] In Nigeria and Ghana, *Eneza Education* adapted its AI platform to identify gaps in girls' understanding and prioritize content accordingly. The platform was especially impactful in reaching girls during school closures and in hard-to-reach rural areas. One of the most significant benefits of AI in education is its ability to provide personalized learning on a massive scale. This allows girls, in particular, to learn at a pace that suits them best, free from the fear of judgment. AI-driven tools can also be incredibly accessible, as they can be deployed on low-bandwidth or even SMS-based systems, making them a viable option in regions with unreliable or non-existent internet infrastructure. However, these promising benefits are accompanied by notable challenges. AI can inadvertently deepen existing inequalities if girls have less access to essential technology like mobile phones or the internet. Furthermore, the algorithms that power these systems often require vast amounts of data for training. If this data isn't carefully disaggregated by gender, the resulting recommendations and learning paths can be biased, failing to adequately serve the unique needs of girls and potentially reinforcing educational disparities rather than closing them.

Predictive Analytics and Early Warning Systems

Predictive analytics uses AI to process large datasets (attendance, test scores, health data, socio-economic indicators) to forecast student performance, detect learning gaps, and flag students at risk of dropping out. Predictive analytics represent a powerful application of AI in girls' education, allowing for proactive and targeted support. In South Africa and Malawi, for instance, AI models have been trained using school data to identify girls at a high risk of dropping out due to factors like pregnancy, absenteeism, or household responsibilities. Similarly, in Senegal, these tools integrate community health and school attendance data to pinpoint adolescent girls vulnerable to risks such as early marriage or menstruation-related absenteeism, which can often lead to them leaving school. The benefits of this approach are clear and impactful. It empowers teachers and social workers to intervene proactively, rather than reactively, and enables the targeted allocation of resources like scholarships or counseling to the girls who need them most. For policymakers, these data-driven insights are invaluable, helping them design more effective, gender-specific educational programs. However, this technology is not without its challenges. The models are only as good as the data they are trained on, and this requires access to high-quality, ethically sourced, and privacy-protected data—which is often a significant hurdle. There is also the risk of models being inaccurate or biased if they fail to account for the complex socio-cultural context of girls' lives. Without a nuanced understanding of these factors, an AI system could make flawed predictions, potentially leading to misdirected interventions or, worse, a reinforcement of existing inequalities.

Intelligent Tutoring Systems (ITS)

ITS are AI-powered software that simulate one-on-one human tutoring. They provide customized guidance, hints, and feedback to help learners master a topic. Intelligent Tutoring Systems (ITS) are proving to be a powerful tool in advancing girls' education. In Rwanda, for example, these platforms have been successfully used to tutor girls in STEM subjects like algebra and physics. By adapting their teaching methods based on each student's responses, these systems provide personalized, step-by-step explanations that significantly improve comprehension. In Ethiopia, ITS tools have been made even more effective by incorporating local languages and cultural references, which helps make the lessons more relatable and engaging for girls in rural communities. This approach offers numerous benefits. ITS provides a low-cost and highly scalable alternative to traditional human tutoring, making quality instruction more accessible. By offering a supportive environment, these systems also help build girls' confidence in subjects that are often male-dominated. Furthermore, because they can be used outside of a traditional classroom setting, ITS can be an invaluable resource for girls who are out of

school. However, there are also challenges to consider. Developing high-quality ITS requires significant resources and expertise, which can be a barrier for many regions. Additionally, while these systems are intelligent, they often lack the emotional intelligence and cultural nuance of a human teacher. This limitation can hinder their effectiveness, especially in sensitive learning contexts where a deeper, more empathetic understanding is needed.

Natural Language Processing (NLP) and AI Chatbots

Natural Language Processing (NLP) is a branch of AI that allows computers to understand, interpret, and respond to human language. In education, this technology enables the creation of tools like chatbots, voice-based learning platforms, and real-time translation services. A great example of this is the UmojaAI pilot in Tanzania, where girls were able to use NLP-powered systems via SMS or WhatsApp to ask questions about their schoolwork, health, or even sensitive gender-based issues. The system provided immediate answers and, for complex problems, seamlessly connected them to a human counselor. We also see multilingual AI tools leveraging NLP to help girls with low initial literacy by allowing them to switch between English and their local African language, making it easier for them to transition into formal schooling. This approach offers some powerful benefits. It promotes autonomous learning and problem-solving, giving girls the confidence to seek out information on their own. It also creates a safe and anonymous channel for them to discuss sensitive topics like menstruation, abuse, or family pressure, which they might be hesitant to bring up in person. Additionally, it promotes digital literacy in a very natural, conversational way. However, there are significant challenges to overcome. NLP models often struggle with African languages due to a severe lack of training data. This can lead to a system that underperforms or fails to grasp the nuances of local dialects. Furthermore, if not carefully monitored, these chatbots can provide incomplete or inappropriate answers, which could be misleading or even harmful, especially when dealing with sensitive topics.

AI-Based Content Recommendation and Curation Systems

Recommendation systems are AI-powered tools that analyze a student's learning patterns and behavior to suggest the most relevant resources, such as videos, articles, or exercises.[1] This personalized approach has a direct application in girls' education. In Nigeria, a UNICEF pilot program used an AI platform to recommend age-appropriate science content to girls, tailoring the suggestions based on their past interactions and quiz results. In Kenya, a similar initiative leveraged AI to help learning resource curators prioritize gender-sensitive content that aligned with the national curriculum.

This approach offers significant advantages. It helps to streamline the learning process by filtering out irrelevant or overly advanced material, and it keeps girls engaged with a continuous stream of tailored recommendations. This self-paced, inquiry-based learning is especially beneficial for girls who have to balance their schoolwork with household responsibilities. However, there are also serious challenges to address. If the recommendation algorithms are trained on biased data, they can inadvertently reinforce stereotypes. For instance, an algorithm might suggest less challenging material to a girl than to a boy, based on societal biases rather than her actual ability. Additionally, these systems often require continuous internet access and a large library of content to be effective, which can be a barrier in resource-constrained environments.

Computer Vision and AI for Learning Assessment

Computer vision, an AI technology that allows computers to "see" and interpret visual data, is finding new applications in education. It is being used to automatically grade handwritten assignments, analyze facial expressions, and monitor classroom engagement. In a pilot study in Uganda, computer vision was used to assess girls' engagement levels during online classes by analyzing their facial expressions and attention span. This provided real-time feedback on how well they were connecting with the material. Additionally, tools using Optical Character Recognition (OCR) have been used to evaluate handwritten assignments, a particularly beneficial application for girls in informal education settings who have less access to digital devices. The benefits of these tools are significant. They offer real-time,

objective feedback on learner engagement and performance, and they free up teachers from the tedious task of grading, allowing them to provide more personalized human support. By using a uniform, algorithm-based grading system, computer vision can also improve equity in assessment. However, the use of computer vision in education raises some serious challenges. There are significant privacy and surveillance concerns, as these systems are constantly monitoring students. Furthermore, the technology may not function well in the low-light or low-resolution environments that are common in many rural schools, which could limit its effectiveness and accessibility where it is needed most.

The Table 1 provides a clear overview of how various AI technologies can be applied in girls' education, outlining their primary uses, benefits, and associated challenges. From this data, a powerful inference can be made: while AI holds immense potential to revolutionize girls' education by offering personalized learning, early intervention, and a safe space for inquiry, this potential can only be fully realized if the ethical and practical challenges are proactively addressed. The benefits, such as individualized pace and targeted support, are significant, but they are consistently undercut by issues of bias in training data, limited access to technology and connectivity, and the need for culturally sensitive and emotionally intelligent design. In essence, the table suggests that the success of AI in bridging educational gaps for girls in Africa depends less on the technology itself and more on the thoughtful, equitable, and context-aware implementation of that technology.

Table 1. Overview of how AI can be applied to Girls' Education

AI Technology	Primary Use	Benefits for Girls	Challenges
Adaptive Learning Systems	Personalized instruction	Learns at own pace, accessible via mobile	Device and data access inequality
Predictive Analytics	Early risk identification	Early intervention for dropouts, better resource targeting	Biased/incomplete data
Intelligent Tutoring Systems (ITS)	Simulated one-on-one tutoring	STEM support, confidence boost	Lacks emotional/cultural depth
NLP & Chatbots	Language learning, mentorship, queries	Safe, anonymous learning space	Limited local language models
Recommendation Engines	Learning content delivery	Self-paced and interest-aligned learning	Risk of stereotype reinforcement
Computer Vision	Engagement and handwriting assessment	Real-time feedback, equitable grading	Privacy and tech infrastructure limitations

The diverse range of AI tools being deployed in African educational contexts demonstrates both innovation and a response to local needs. What's clear is that the most impactful technologies are those that are designed to be inclusive, can adapt to low-resource environments, and are sensitive to the specific barriers girls face. While AI won't replace human teachers or fundamental systemic reforms, it can be a powerful tool for amplifying equity, personalization, and access when implemented with a strategic and thoughtful approach. To truly harness the benefits of AI for girls in Africa, future initiatives must move beyond a one-size-fits-all model. It is essential to incorporate gender-specific datasets from the outset, actively engage girls and women in the design and testing of new tools, and prioritize the development of systems with offline capabilities and local language integration. These steps are crucial to ensure that AI technology is not only effective but also culturally relevant and accessible to the most vulnerable learners.

Challenges in Implementation of AI Technologies in Girls' Education in Africa

While artificial intelligence (AI) holds transformative potential for advancing girls' education in Africa, its implementation faces a host of multifaceted challenges. These challenges span technological, infrastructural, cultural, ethical, and policy domains, and they often intersect in ways that compound their impact on the most vulnerable learners—especially

girls in rural and underserved communities. This section outlines the major challenges that have hindered or complicated the implementation of AI-based educational interventions targeting girls across various African contexts, based on the reviewed literature.

Digital Infrastructure Deficits

One of the most fundamental barriers to AI deployment in education is the persistent lack of digital infrastructure in many African regions. Electricity and Connectivity: Many rural schools operate without reliable electricity or internet access. AI tools—particularly those requiring real-time data processing, cloud-based services, or frequent updates—are often rendered unusable in such environments.[6] Girls are especially disadvantaged as households are less likely to invest in digital infrastructure for female children. Even where internet is available, girls frequently lack access to personal devices such as smartphones, tablets, or computers due to poverty or gender-biased resource allocation within families.[3] A study in Nigeria revealed that only 34% of girls in low-income communities had access to any digital device, compared to 62% of boy.[4] Many AI tools are optimized for high-speed internet, but connectivity in remote or conflict-prone areas is often slow and unreliable. Without offline or edge-AI capabilities, these technologies exclude a vast population of girls.

The Digital Gender Divide

The digital gender divide disparity in digital access, literacy, and participation between males and females—is a major barrier to the successful implementation of AI in education for girls. In several African societies, cultural beliefs dictate that girls should focus on domestic roles, discouraging them from engaging with technology. These norms not only limit girls' use of AI tools but also reduce parental or community support for such initiatives. AI tools often assume a baseline level of digital literacy. Yet, girls—especially those in rural settings—often lack basic skills such as navigating applications, typing, or using digital learning interfaces. Without targeted training, they are unable to benefit fully from AI-enhanced learning platforms. Girls face a heightened risk of online harassment and exploitation, which deters both them and their guardians from engaging with digital education platforms, particularly those that are not moderated or lack safe user policies.

Data Bias and Invisibility

AI systems are only as effective as the data they are trained on. When datasets are incomplete, unrepresentative, or biased, the resulting AI tools can perpetuate or even exacerbate inequalities. Most AI educational tools are trained on datasets that lack gender-disaggregated data, or worse, datasets sourced from global north populations with little relevance to African girls' realities. This leads to recommendations or feedback loops that misrepresent female learners' needs and performance.[10] Biases embedded in AI algorithms can disproportionately affect girls. For instance, dropout prediction models may underpredict dropout risk for girls if they don't factor in gendered challenges like menstruation-related absenteeism or caregiving roles. The use of personal data—particularly health, behavioral, and socio-economic data of minors—raises significant privacy and consent concerns. Girls in many contexts may not have the agency or literacy to understand or opt out of data collection, which violates ethical principles.

Lack of Local Language and Cultural Adaptation

Many AI tools are developed in English or French, creating an accessibility gap for girls in rural areas who speak indigenous languages. Without robust Natural Language Processing (NLP) support for local dialects, many girls are excluded from meaningful engagement with the technology.[8] Educational AI systems often lack cultural contextualization, using content, examples, or pedagogy styles that are unfamiliar or irrelevant to African learners. This limits learner engagement, particularly among girls who may already feel alienated from formal schooling environments.

Teacher Readiness and Resistance

The successful implementation of AI in education depends heavily on the willingness, ability, and confidence of teachers to adopt and integrate new technologies. Most teachers—especially in public schools—have not received adequate training on how to use AI tools in the classroom. This often leads to underutilization or misapplication of available technology. Some educators express concern that AI tools might eventually replace them or undermine their

authority, leading to resistance or passive non-compliance with implementation guidelines. In some instances, male teachers—who dominate the teaching workforce in STEM subjects—may unconsciously discourage girls from engaging with AI tools or may prioritize male learners when facilitating tech-driven learning.

Fragmented and Gender-Blind Policy Frameworks

Most national AI and edtech strategies in Africa are technology-centric rather than equity-driven. They fail to include explicit goals for improving access and outcomes for girls. Many AI-in-education projects targeting girls are limited to small-scale pilots, often funded by NGOs or development agencies. These projects lack integration into national curricula or budgets, leading to discontinuity once external funding ends.[5] The absence of comprehensive data protection laws in many countries leaves room for misuse of students' personal information, with girls being particularly vulnerable due to their lower agency in digital spaces.

Financial Sustainability and Cost Constraints

Designing and deploying AI tools—especially those with features like NLP, real-time analytics, and offline capabilities—requires significant investment. Schools serving low-income populations often lack the financial means to purchase or maintain AI infrastructure. For girls from low-income households, costs related to internet data, charging devices, or accessing premium versions of educational apps pose serious barriers to sustained use. Many programs remain heavily reliant on donor funding without clear sustainability or scale-up plans. This creates volatility in access and availability, which affects girls more than boys due to their lower resilience to educational disruption.

The table 2 highlights that the key challenges to implementing AI in girls' education in Africa are not primarily technological, but rather social, structural, and cultural. The biggest hurdles—infrastructure deficits, the digital gender divide, and language barriers—are all external to the AI itself. Furthermore, even when AI is deployed, issues like biased data and gender-blind policies can actively undermine its potential. This suggests that for AI to be a truly effective tool for equity, its implementation must be part of a broader strategy that addresses fundamental issues of infrastructure, digital inclusion, and policy reform, rather than being treated as a standalone solution.

Table 2. Key Challenges to Implement AI

Challenge	Impact on Girls' Education
Infrastructure deficits	Limits access to AI tools, especially in rural schools and homes
Digital gender divide	Girls have less access to devices and digital literacy opportunities
Biased or poor-quality data	AI tools misrepresent or fail to address girls' specific learning needs
Language and cultural mismatch	Reduces relevance and engagement among girls, especially in rural settings
Teacher capacity and resistance	Weakens tool adoption and perpetuates gender bias in tech-mediated learning
Gender-blind policies	Fails to target or prioritize girls in national AI education strategies
Cost and sustainability issues	Limits scalability and long-term access, especially for the poorest learners

The implementation of AI in education for girls in Africa is a complex and multi-layered endeavor, fraught with structural, socio-cultural, and technological challenges. Addressing these barriers requires a holistic, intersectional approach that prioritizes equity from design to deployment. Stakeholders—including policymakers, developers, educators, and communities—must work collaboratively to co-create AI tools that are ethical, inclusive, and sustainable. Without targeted efforts to bridge these gaps, AI may inadvertently entrench existing inequalities rather than dismantle them. However, when carefully designed and contextually adapted, AI has the potential to become a powerful equalizer in girls' education across the African continent.

Contextual and Policy Enablers for AI-Driven Girls' Education in Africa

Despite the numerous challenges facing the implementation of artificial intelligence (AI) in

educational initiatives across Africa, several contextual and policy enablers have proven instrumental in facilitating success, particularly in programs targeting improved learning outcomes for girls. These enabling factors include supportive government policies, inclusive community practices, public-private partnerships, and innovations in technology that adapt to African realities. When these elements align, AI-driven interventions become more scalable, sustainable, and impactful. This section highlights the key structural, institutional, and policy-level enablers that have supported the successful deployment of AI tools to promote girls' education in Africa.

Government Policy Frameworks Supporting EdTech and Gender Inclusion

Governments play a critical role in setting national agendas for digital transformation and educational equity. In countries where AI and education policies include explicit gender equity targets, there has been more coordinated and impactful integration of AI tools into the education system. Kenya's Digital Literacy Programme (DLP) is a leading example. The initiative included a gender lens from the outset, ensuring that digital devices were distributed equitably among boys and girls. It also included teacher training on gender-responsive pedagogy using digital tools. This helped create an enabling environment for later AI integrations, such as M-Shule and Eneza Education, both of which have reached tens of thousands of girls in low-income communities. In Rwanda, the Smart Rwanda Master Plan (2016–2020) emphasized ICT adoption in education with clear provisions for female inclusion in STEM and digital skills programs. This policy backing enabled partnerships with global AI education platforms and facilitated access to funding for AI pilots targeting girls in rural areas. Ghana's ICT in Education Policy integrates gender and inclusion as cross-cutting themes, encouraging developers and schools to design technology initiatives that directly address girls' learning needs. When national policies incorporate gender equity as a core priority rather than a secondary concern, they create stronger incentives for implementers and funders to develop inclusive AI tools. Policies that go beyond hardware provision—addressing teacher training, curriculum content, and monitoring frameworks—are especially effective in sustaining gender-responsive AI applications.

Community Engagement and Sociocultural Buy-In

In contexts where community leaders, parents, and traditional institutions support girls' education and digital inclusion, AI interventions have a higher chance of success. In Senegal and Ethiopia, community-based learning hubs supported by NGOs and local governments provided offline AI-assisted learning platforms in safe, culturally accepted settings. The presence of female mentors, flexible schedules, and learning content in local languages significantly increased girls' attendance and engagement. Parental involvement has also emerged as a strong enabler. In Nigeria, SMS-based AI tutoring systems sent regular performance updates to parents, helping them track their daughters' progress and reinforcing the importance of education at home. This model increased girls' lesson completion rates by over 30% compared to control groups.[4] In some communities, the endorsement of local religious or tribal leaders has led to a marked shift in perceptions about girls' use of technology—redefining it as a tool for empowerment rather than cultural rebellion. Community-level engagement is crucial to mitigating resistance stemming from cultural norms and to building trust in AI-enabled education programs. Programs that treat communities as partners—not just beneficiaries—see higher acceptance and long-term sustainability.

Public-Private and Multi-Sector Partnerships

The complexity of deploying AI in education—especially in marginalized settings—requires collaboration between government, civil society, technology developers, and international donors. Several successful initiatives demonstrate the power of such partnerships. In Ghana, a collaboration between the Ministry of Education, UNICEF, and edtech startups enabled the deployment of AI chatbots that delivered interactive learning materials to girls during COVID-19 school closures. These tools helped maintain learning continuity for over 50,000 students. In Tanzania, partnerships between local universities, NGOs, and global AI labs supported the development of localized Natural Language Processing (NLP) tools, ensuring that AI platforms were linguistically and culturally aligned with users' needs—especially young girls in rural communities. The African Union's Digital Transformation Strategy (2020–2030) encourages

member states to foster Pan-African cooperation on AI, facilitating cross-border partnerships and pooling of resources to develop shared AI models that address common educational challenges, including gender inequality. Collaborations that leverage the strengths of different sectors—technical innovation, policy influence, field implementation, and funding—create more resilient and responsive AI ecosystems. Partnerships also help bridge knowledge gaps between local educators and AI developers, ensuring tools are built for the realities on the ground.

Innovations in Low-Tech and Offline AI Solutions

A significant enabler for AI in girls' education has been the rise of low-tech, offline-capable, and mobile-first AI solutions that work within Africa's digital limitations. SMS-based platforms such as *M-Shule* and *Ustad Mobile* leverage basic mobile phones to deliver adaptive learning content in text format. These tools have shown remarkable success in reaching girls in low-connectivity areas who do not have access to smartphones or computers. The development of edge-AI systems—which perform computations locally without needing continuous internet—has allowed for real-time learning analytics and feedback even in schools without reliable networks. Solar-powered digital classrooms and portable learning kits equipped with AI software have been deployed in parts of Malawi and Zambia to overcome electricity barriers, enabling consistent access to AI-enhanced education for girls. Technological innovation that prioritizes accessibility, affordability, and inclusivity enables AI systems to function in real-world African conditions. These tools are not just alternatives—they are essential innovations for equity-focused education.

Monitoring, Evaluation, and Evidence-Based Scaling

Evidence-based planning has emerged as a key enabler for sustainable implementation. Successful AI programs often include robust monitoring and evaluation frameworks that track usage patterns, learning outcomes, and gender-specific impacts. These insights are used to improve the systems iteratively and build the case for scale-up. For instance, an AI-powered reading program in Uganda implemented by a local NGO and evaluated by an international research consortium used gender-disaggregated learning analytics to refine curriculum delivery and identify systemic barriers unique to girls. This led to an increase in girls' reading comprehension scores by 38% over 9 months. Governments and donors are increasingly requiring proof of gender impact as part of funding criteria, which incentivizes developers to adopt inclusive AI design principles. Transparent, gender-responsive evaluation processes help identify what works and what doesn't. They also provide the evidence base needed to scale promising interventions nationally or regionally.

The Table 3 clearly demonstrates that the success of AI in girls' education in Africa is not a given; it is actively enabled by a supportive ecosystem. The most critical inference is that technology alone is insufficient. The effectiveness and sustainability of AI initiatives are directly tied to human and institutional factors. Specifically, the table highlights that success hinges on creating gender-inclusive policy frameworks, securing community and parental buy-in, and forming public-private partnerships. The most impactful innovations are those that prioritize low-tech, offline solutions that are accessible to all, and are continually refined through evidence-based monitoring. In essence, for AI to truly empower girls, it must be embedded within a holistic strategy that addresses the social, political, and economic contexts in which they live.

While the road to AI-enhanced education for girls in Africa is complex, the presence of strategic enablers can greatly accelerate success and sustainability. These enablers demonstrate that AI is not just a technological solution—it is a systemic innovation that requires alignment between policy, culture, infrastructure, and human capital. By building on these foundations, stakeholders can unlock AI's full potential as a tool for transformational change in girls' education, contributing meaningfully to both SDG 4 (Quality Education) and SDG 5 (Gender Equality).

Table 3. Summary of Key Enablers

Enabler	Impact on Girls' AI Education
Gender-inclusive policy frameworks	Institutionalizes equity and creates incentives for gender-responsive design
Community and parental engagement	Enhances cultural acceptance and boosts girls' participation and persistence
Public-private partnerships	Enables resource pooling and innovation tailored to local needs
Low-tech, offline AI innovations	Makes AI tools accessible in low-resource and rural environments
Evidence-based monitoring and evaluation	Supports data-driven improvements and long-term scaling of effective programs

The Table 4 shows clearly that AI's impact on girls' education is a multifaceted issue. The findings suggest that AI can be a powerful force for good, as seen in improved learning outcomes and retention rates for girls. However, this success is not guaranteed and hinges on the careful implementation of specific technology types—such as Intelligent Tutoring Systems (ITS) and chatbots—that are designed to be relevant and accessible. The table also underscores that the real obstacles aren't technical, but rather systemic and social. Challenges like inadequate infrastructure, the digital gender divide, and algorithmic bias can severely limit AI's potential. This leads to the central inference: the effectiveness of AI in bridging educational gaps for girls in Africa is fundamentally dependent on a holistic approach. It's not enough to simply deploy technology; success requires strategic investment in infrastructure, strong multi-stakeholder partnerships, and inclusive policies that actively mitigate bias and ensure the technology is both accessible and culturally aligned with the communities it serves.

Table 4. Summary of Implementation Challenges

Theme	Findings	Implications
Learning Outcomes	AI improves literacy, numeracy, and retention among girls when contextually applied	Tailored AI tools can narrow gender achievement gaps
Technology Types	ITS, predictive analytics, and chatbots dominate implementations	Tools must evolve to include gender-relevant content and offline access
Challenges	Infrastructure, digital divide, algorithmic bias, weak policy	Need for holistic ecosystem investment and bias mitigation
Enablers	Community models, government policies, multi-stakeholder partnerships	Local alignment and inclusivity drive AI success

The evidence suggests that AI has the potential to serve as a catalytic tool for advancing girls' education in Africa—but only when designed with a clear understanding of contextual, gender-specific, and infrastructural realities. Isolated technology deployments are insufficient; sustainable impact emerges from integrated approaches that prioritize equity, cultural sensitivity, and local ownership. Future research should prioritize longitudinal impact studies, integrate intersectional gender analysis, and explore how AI ethics frameworks can be adapted for low-resource, high-inequality settings.

CONCLUSION

This study has comprehensively examined the role of artificial intelligence (AI) in enhancing learning outcomes for girls in Africa, drawing on a synthesis of 27 peer-reviewed studies, reports, and empirical cases. Our findings provide compelling evidence that AI, when designed and implemented inclusively and contextually, has the potential to significantly transform educational opportunities for marginalized girls across the continent. Based on the comprehensive review, several key conclusions emerge about the role of AI in girls' education in Africa. Our most significant finding is that AI has the potential to dramatically improve academic outcomes, retention, and engagement for girls, particularly in subjects like math and science.

However, this isn't a given. Success is tied to the intentional design of AI tools, specifically those that offer adaptive learning, use predictive analytics to identify girls at risk of dropping out, and are accessible via mobile or offline platforms. This is consistent with global research on personalized learning, but our study goes a step further by highlighting that for African girls, these tools are most effective when integrated with broader support systems and culturally appropriate design.

A critical takeaway is that the effectiveness of AI is deeply dependent on the ecosystem in which it operates. Technology simply cannot succeed in isolation. The most sustainable and impactful initiatives were those supported by gender-inclusive national policies, strong community engagement that involved parents and local leaders, and collaborative partnerships between governments, NGOs, and AI developers. This finding reinforces principles from the broader ICT for Development (ICT4D) literature, emphasizing that a human-centered, community-driven approach is essential for any technology to take root and thrive. While the promise of AI is clear, we cannot ignore the significant barriers that continue to limit its reach and equity. These include fundamental infrastructure deficits like unreliable electricity and poor connectivity, as well as the digital gender divide that leaves girls with less access to devices and digital literacy training. Furthermore, inherent issues like algorithmic bias from unrepresentative data and a lack of local language support in AI tools can undermine even the best intentions. Our review shows that when these factors are ignored, AI interventions can have neutral or even negative outcomes, as seen in the case of a pilot in Zambia that failed because the tool was only in English.

This review, while comprehensive, has its own limitations that are important to acknowledge. Our findings are heavily skewed towards Anglophone countries, with less data available from Francophone or Lusophone Africa. We also found a scarcity of long-term studies, making it difficult to assess sustained impact, and a lack of consistently disaggregated data. These limitations, however, point the way for future research and action. We urge researchers to conduct more rigorous, longitudinal studies that track long-term outcomes and to explore AI co-design methodologies that actively involve girls and their communities. For policymakers, we recommend a move toward gender-responsive AI strategies that include mandatory gender audits, the development of localized tools, and policies that incentivize inclusive collaborations. For developers and the general public, our findings stress the importance of designing tools with offline functionality and multilingual support, and fostering community engagement to build trust and bridge the digital divide. In essence, this study is not just about the "what" of AI in girls' education, but the "how." It extends prior research by placing girls' experiences at the center and argues that success is not merely a technical achievement but a social and political one, requiring a concerted effort to build an equitable and enabling ecosystem around the technology. In summary, AI has the potential to be a game-changing tool for advancing girls' education in Africa, but its success is not automatic. Equity must be engineered into its design, deployment, and governance. AI alone cannot overcome structural barriers—but when paired with inclusive policies, community engagement, and technological innovation tailored to local needs, it can amplify access, personalize learning, and unlock new pathways for educational transformation. This study contributes a vital piece to the growing field of AI for inclusive education, calling for deeper collaboration across sectors and disciplines to ensure no girl is left behind in the digital age.

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CONFLICT OF INTEREST

The author declares that the there are no competing interest related to this work.

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