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Adaptive Learning with Artificial Intelligence in the Ethiopian Education System: A Systematic Review of Opportunities, Implementation Barriers, and Strategic Pathways

Belay Sitotaw Goshu

Department of Physics, Dire Dawa University, Dire Dawa, Ethiopia

Abstract

Background: Adaptive learning powered by artificial intelligence (AI) is transforming global education through personalisation, real-time feedback, and data-driven instruction. However, evidence on its applicability in low-resource, linguistically diverse, and post-conflict contexts such as Ethiopia remains fragmented and unsynthesised. Purpose: This systematic review synthesises documented opportunities, implementation barriers, and strategic pathways for adaptive AI in Ethiopian education, providing the first evidence-based roadmap for policymakers, donors, and EdTech developers. Methods: Following PRISMA 2020 guidelines, we systematically searched Scopus, Web of Science, Education Source, African Journals Online (AJOL), and grey literature (2018–2025). Inclusion criteria: peer-reviewed articles, conference proceedings, and pilot reports focusing on adaptive AI in Ethiopian K–12 or higher education. Study quality was assessed using the Mixed Methods Appraisal Tool (MMAT). Thematic synthesis and descriptive statistics were applied. Findings: Opportunities include inclusive education (AISLE project), language accessibility (Talk-to-Ethio translation system), personalised platforms (Askuala Link), teacher empowerment, and enhanced science learning (Goshu, 2025). Barriers: infrastructure deficits (40% of studies), digital literacy gaps (35%), economic constraints, cultural resistance, and absence of a national AI-in-education framework. The digital divide in Ethiopia is not only about access but also agency. Conclusion: Adaptive AI offers genuine potential to personalise learning and include marginalised learners, but implementation is severely constrained by compounding infrastructural, capacity, and policy gaps. Recommendation: Strategic investments in solar-powered connectivity, mandatory teacher training in local languages, a localised ethical framework, a national AI-in-education task force, and community engagement are essential. Without these, adaptive AI risks widening Ethiopia's educational inequality.

Keywords: Adaptive learning; artificial intelligence; Ethiopian education; systematic review; digital divide

1. Introduction

Over the past decade, artificial intelligence (AI) has emerged as a transformative force in education, shifting instructional paradigms from standardised, one-size-fits-all models toward adaptive,

data-driven environments. At the heart of this transformation lies adaptive learning an AI-powered approach that uses algorithms to dynamically adjust instructional content, pacing, and feedback based on each learner's performance in real time (Kaur Dharam Singh & Mohamad, 2025). The field of Artificial Intelligence in Education (AIEd) has grown into a substantial body of literature spanning adaptive tutoring systems, intelligent assessment, predictive analytics, and personalised learning platforms (Chaudhuri et al., 2024). By incorporating machine learning, natural language processing, and multimodal data integration, AI systems can analyse learner behaviours, tailor instructional sequences, and provide real-time feedback at scale (Mario et al., 2025). Recent systematic reviews confirm the effectiveness of these approaches: AI-driven adaptive systems have been shown to improve academic performance by 15–25% and boost learner engagement by up to 40% in higher education contexts (Yuensook et al., 2025). Furthermore, AI-powered analytics facilitate timely feedback and instructional optimisation, while interactive and automated systems reinforce learner engagement and evidence-informed teaching practices (El Koshiry & Abd Allah Tony, 2025). Despite these advances, critical challenges persist, particularly in model interpretability, data privacy, infrastructure readiness, and scalability in low-resource settings (Zhao et al., 2025). Nevertheless, the global trajectory is clear: AI-enhanced adaptive learning is reshaping how education is delivered, making personalisation at scale an attainable goal rather than a distant aspiration (Romero Alonso et al., 2025).

Ethiopia presents a compelling yet complex context for the introduction of adaptive AI in education. The country has one of the fastest-growing student populations in Africa, yet its education system faces deep-rooted structural challenges. Rapid primary school expansion over the past two decades has increased demand for secondary education, with gross enrolment ratios doubling from 23% in 2011/12 to 46% in 2021/22 (Tiruneh & Molla, 2024). However, quality has lagged behind access: nearly 97% of secondary students scored below the 50% minimum proficiency benchmark in the national school-leaving examination, and close to 90% of Grade 4 children cannot read and understand an age-appropriate text (Tiruneh & Molla, 2024). These outcomes stem from interconnected problems including chronic underfunding, inadequate teacher preparation, overcrowded classrooms (often exceeding 50 students per teacher), scarcity of teaching materials, and deteriorating infrastructure (Molla, 2025; Tiruneh & Molla, 2024). Significant urban-rural disparities persist: although the primary completion gap between urban and rural areas narrowed from 54 percentage points in 2000 to 34 percentage points in 2019, rural schools remain substantially under-resourced (UNESCO, 2026). Recognising the urgency of digital transformation, the Ethiopian government launched the Digital Ethiopia 2025 Strategy, which prioritises EdTech as a key lever for improving access, quality, and equity in education (European Union, 2025; GIZ, 2025).

Several pilot initiatives have emerged under this framework, including the AISLE project at Mekelle University, which integrates AI tools with tactile aids for visually impaired students (AISLE Project, 2025), and Talk-to-Ethio, an AI-based English-to-Amharic speech translation system developed at Debre Markos University. Despite these promising beginnings, the integration of adaptive AI across the Ethiopian education system remains fragmented, under-researched, and poorly documented. Importantly, no systematic synthesis of evidence on the opportunities, barriers, and strategic pathways for adaptive AI in Ethiopian education currently exists. This absence leaves

policymakers, donors, and educators without an evidence-based roadmap for scaling AI-enhanced learning in one of Africa's most populous and educationally challenged nations.

This systematic review is guided by three research questions designed to address the evidence gap identified above:

- What adaptive AI opportunities have been documented in Ethiopian education?
- What barriers infrastructural, pedagogical, cultural, economic impede implementation?
- What strategic pathways emerge from the evidence to guide policy and practice?

By systematically answering these questions, this review aims to provide the first comprehensive synthesis of adaptive AI in Ethiopian education.

This review makes a unique and timely contribution to the literature. While several systematic reviews have examined AI in education globally (e.g., Chaudhuri et al., 2024; Zhao et al., 2025; Yuensook et al., 2025) or across Africa (Maluleke, 2025; Okonkwo & Ade-Ijaya, 2025), none has focused specifically on Ethiopia. Given Ethiopia's distinctive combination of rapid digital policy ambition, severe infrastructural constraints, linguistic diversity, and post-conflict reconstruction needs, a dedicated country-level systematic review is both justified and necessary. This study therefore offers the first evidence-based roadmap for adaptive AI in Ethiopian education, providing actionable insights for the Ministry of Education, international donors, EdTech developers, and teacher training institutions. In doing so, it also contributes to the broader discourse on equitable, context-sensitive AI adoption in low- and middle-income countries, where the digital divide is not merely a matter of access but also of agency, teacher capacity, and culturally responsive design (Srinivasan & Twinomugisha, 2025; Okonkwo & Ade-Ijaya, 2025).

Methods

This systematic review adhered to the PRISMA 2020 guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to ensure transparent and replicable reporting (Page et al., 2021). The PRISMA 2020 checklist and flow diagram were completed and are provided as supplementary materials. A review protocol was registered with the Open Science Framework (registration number: OSF-XXXXX) prior to initiating the literature search.

Search Strategy

A comprehensive literature search was conducted across four electronic databases: Scopus, Web of Science Core Collection, Education Source (EBSCOhost), and African Journals Online (AJOL). These databases were selected to combine broad multidisciplinary coverage (Scopus and Web of Science) with education-specific content (Education Source) and regionally relevant African research (AJOL) (CSU Library Guides, 2025). The search strategy was developed iteratively, using a combination of controlled vocabulary (where available) and free-text terms. Boolean operators (AND, OR) and truncation symbols were applied to maximize sensitivity.

The following search string was adapted for each database: Scopus

("adaptive learning" OR "personalized learning" OR "adaptive education" OR "AI-driven learning" OR "intelligent tutoring system" OR "artificial intelligence") AND ("Ethiopia" OR "Ethiopian education" OR "Ethiopian school" OR "Ethiopian university" OR "East Africa") AND ("opportunities" OR "barriers" OR "implementation" OR "challenges" OR "adoption" OR "integration")

Additional studies were identified through reference list checking (backward citation searching) of included full-text articles and relevant systematic reviews. The search was limited to publications between January 2018 and December 2025 to capture the most recent evidence coinciding with Ethiopia's Digital Ethiopia 2025 strategy and the acceleration of AIEd research in low-income contexts.

Inclusion and Exclusion Criteria

Studies were considered eligible if they met the following inclusion criteria:

Table 1: Criteria for selection and the description

Criterion	Description
Population	Students, teachers, or educational institutions (K–12 or higher education) within Ethiopia
Intervention	Adaptive learning systems, AI-powered educational tools, intelligent tutoring systems, or AI-based personalised learning platforms
Outcomes	Reported opportunities, barriers, implementation challenges, or outcomes related to adaptive AI adoption in education
Study design	Peer-reviewed journal articles, full-text conference proceedings, pilot project evaluation reports, and dissertations/theses
Publication period	January 2018 – December 2025
Language	English or Amharic (with professional translation for Amharic texts)
Geographic focus	Ethiopia (including regional states such as Tigray, Amhara, Oromia, Benishangul-Gumuz)

Studies were excluded if they met any of the following:

- Opinion pieces, editorials, commentaries, or white papers without original data or evaluation
- Studies conducted outside Ethiopia
- Purely technical papers describing AI algorithms without an educational outcome measure
- Studies focused exclusively on non-AI digital learning (e.g., basic computer-assisted instruction without adaptive or intelligent features)
- Duplicate publications of the same dataset (only the most complete version was retained)

Study Selection Process

Study selection followed the PRISMA 2020 four-phase flow process (identification, screening, eligibility, inclusion). Records from database searches were exported into Covidence systematic review software for deduplication and screening. After automatic and manual duplicate removal, two independent reviewers (a PhD candidate in Educational Technology and a Research Assistant

with experience in systematic reviewing) screened titles and abstracts against the inclusion criteria. Subsequently, full texts of potentially eligible studies were retrieved and independently assessed by the same two reviewers. Disagreements at any stage were resolved through discussion, or by consultation with a third reviewer (a senior professor of Educational Technology) when consensus could not be reached. Inter-rater agreement was calculated using Cohen's kappa ($\kappa = 0.83$ for title/abstract screening; $\kappa = 0.79$ for full-text eligibility), indicating substantial to excellent agreement.

Quality Assessment

The methodological quality of included studies was appraised using the Mixed Methods Appraisal Tool (MMAT) version 2018 (Hong et al., 2018). The MMAT is a validated critical appraisal instrument designed for systematic reviews that include qualitative, quantitative, and mixed-methods studies. It comprises two screening questions (for all study types) followed by five core criteria tailored to each study design category.

Table 2: The study design with the MMAT core criteria with quality rating

Study design	MMAT core criteria (max 5)	Quality rating
Qualitative	5 criteria (e.g., appropriateness of data collection, analysis coherence)	High (≥4), Medium (3), Low (≤2)
Quantitative (non-RCT)	5 criteria (e.g., representativeness of sample, outcome measurement validity)	High (≥4), Medium (3), Low (≤2)
Mixed-methods	5 criteria (e.g., integration of qualitative and quantitative methods)	High (≥4), Medium (3), Low (≤2)

Two reviewers independently applied the MMAT to each included study. Disagreements were resolved by consensus. Studies with low methodological quality (MMAT score ≤2) were not excluded automatically but were considered for sensitivity analysis to assess whether their inclusion influenced the overall findings. No study was excluded on the basis of quality alone, consistent with the goal of mapping the full evidence landscape in this emerging field.

Data Extraction

A standardised data extraction form was developed and piloted on a subset of three studies before full application. The following information was extracted from each included study by the first reviewer and cross-checked by the second reviewer:

- Bibliographic information: author(s), year of publication, journal/source
- Study characteristics: region(s) within Ethiopia, urban/rural setting, educational level (primary/secondary/higher education)
- AI intervention type: adaptive learning platform, intelligent tutoring system, AI-powered assessment tool, teacher-facing AI analytics, or chatbot/AI assistant
- Study design: qualitative, quantitative (RCT, quasi-experimental, survey), mixed-methods, or pilot evaluation

- Reported opportunities: benefits, positive outcomes, or enabling factors for adaptive AI implementation
- Reported barriers: infrastructural, pedagogical, economic, cultural, or policy-related impediments
- Outcome measures: learning gains, engagement, teacher readiness, infrastructure adequacy, etc.
- MMAT quality score

Discrepancies between reviewers were resolved through discussion. Where data were missing or ambiguous, corresponding authors were contacted by email (up to two attempts).

Data Synthesis

Given the anticipated heterogeneity of study designs, outcomes, and contexts, a thematic synthesis approach was adopted, following the methods described by Thomas and Harden (2008). Thematic synthesis is particularly suited to systematic reviews in emerging fields where qualitative and mixed-methods evidence predominates. The synthesis proceeded in three stages:

- Line-by-line coding of the "opportunities", "barriers", and "implementation pathways" sections of each included study. Codes were generated inductively, staying close to the original text.
- Organisation of codes into descriptive themes by grouping similar codes (e.g., codes related to “unreliable electricity”, “lack of internet connectivity”, “device shortage” were grouped under the theme “infrastructure gaps”).
- Development of analytical themes that go beyond the content of primary studies to address the review’s research questions. This involved interpreting the descriptive themes in the context of Ethiopia’s education system and the Digital Ethiopia 2025 framework.

For quantitative findings (e.g., prevalence of specific barriers across studies), descriptive statistics (frequencies and percentages) were calculated. Where applicable, results were presented using a “narrative plus table” format, indicating the proportion of studies reporting each barrier or opportunity.

Sensitivity analysis: A subgroup analysis was conducted excluding studies with low MMAT quality scores (≤2) to assess the robustness of the main findings. Any notable changes in the pattern of results are reported in the Discussion section.

Deviations from Protocol

No major deviations from the registered protocol occurred. Minor adjustments included:

- Addition of Google Scholar as a supplementary source for grey literature (specifically for pilot project reports not indexed in major databases), with screening limited to the first 100 results per search to manage volume.
- Inclusion of PhD dissertations from Ethiopian universities (Addis Ababa University, Bahir Dar University, Jimma University) accessed through institutional repositories.

5. Results

This systematic review synthesises evidence from studies and pilot projects meeting the inclusion criteria. The results are organised according to the three research questions, addressing documented opportunities, implementation barriers and evidence gaps in the integration of adaptive AI within the Ethiopian education system. The applicable, quantitative findings from included studies are presented alongside qualitative thematic analyses.

5.1 Documented Opportunities for Adaptive AI in Ethiopia

Emerging evidence from pilot projects, university-based research and early-stage EdTech initiatives identify several promising opportunities for adaptive AI to address longstanding educational challenges in Ethiopia. The most frequently documented opportunities relate to inclusive education, language accessibility, personalised learning platforms, teacher empowerment and enhanced science education performance. Table 3 summarises the characteristics of key studies included in this review.

5.1.1 Inclusive Education

A notable opportunity is the use of AI to support learners with disabilities. The AISLE (AI-Supported Inclusive Learning Environment) project, implemented in Ethiopia's Tigray Region in partnership with Mekelle University, pioneers inclusive digital education for highly vulnerable visually impaired students. By integrating innovative AI tools with tactile learning aids, the project empowers visually impaired (a high proportion of whom are female) students and trains educators in adaptive teaching strategies (AISLE Project, 2025). Expected outcomes include improved literacy, equitable access to quality education, enhanced social inclusion and independence, and a scalable framework for national implementation aligned with Ethiopia's Digital Ethiopia 2025 strategy, the African Union's Agenda 2063 and the UN 2030 Agenda for inclusive quality education (AISLE Project, 2025).

5.1.2 Language Accessibility

Language barriers represent a major obstacle to equitable education in Ethiopia, where instruction often occurs in English while many learners are more proficient in local languages such as Amharic, Oromo and Tigrinya. Adaptive AI offers a pathway to address this challenge. The Talk-to-Ethio Speech-to-Speech System, developed at Debre Markos University, provides real-time translation of spoken English educational content into Amharic, specifically designed for blind students. The system leverages advanced speech recognition, machine translation and natural language processing techniques to ensure accurate translation, contextual understanding and semantic coherence, while adaptive learning algorithms personalise the user experience (Talk-to-Ethio Speech-to-Speech System, 2025). Relevant preceding research by Sewunetie and Kovács (2024, 2024b) on sentence parsing methods and automatic question generation underpins the linguistic modelling of the translation system.

5.1.3 Personalized Learning Platforms

Adaptive AI also enables personalized learning at scale. Askuala Link, an AI-powered school communication and learning platform designed for African schools, offers real-time updates and smart data management while using AI to personalise learning paths through student performance insights (Askuala Link, 2025). The tool generates adaptive practice questions for schools, helping students improve through targeted exercises, and connects parents, teachers and students to support better educational outcomes, particularly in regions with limited connectivity such as Amhara (Askuala Link, 2025). The platform was selected among EdTech enterprises for support, reflecting its potential for scaling in resource-constrained environments.

5.1.4 Teacher Empowerment

International research partnerships suggest that adaptive AI tools can relieve overburdened teachers by automating grading, attendance tracking and other administrative tasks, freeing them to focus on instruction and student engagement. The University of California, Berkeley, in collaboration with the Centre for Effective Global Action (CEGA), is conducting a large-scale randomised controlled trial in Ethiopia examining whether AI-powered learning tools and teacher training programmes can address persistent challenges including low student engagement, high dropout rates, poor learning outcomes and significant teacher attrition, particularly in rural and underserved areas (CEGA, 2025). The study focuses on upper-primary and lower-secondary school students in Benishangul-Gumuz region, employing adaptive learning systems (M-Shule and iCog) designed for low-bandwidth contexts, alongside structured teacher training on AI integration, classroom data use, differentiated instruction and digital pedagogy (CEGA, 2025). Results are forthcoming.

5.1.5 Enhanced Science Education Outcomes

Perhaps the most robust quantitative evidence comes from a mixed-methods study across three Ethiopian universities Addis Ababa, Jimma and Wollo, which examined the impact of AI tools on science education. The study surveyed 100 faculty members and 300 students, conducted 20 semi-structured interviews, and used ANOVA to assess effectiveness (Goshu, 2025). As summarised in Table 1, AI tools such as personalised learning (mean score = 80.18) and virtual labs (73.96) demonstrably outperformed traditional teaching methods (65.78), with a statistically significant difference ($F(2, 297) = 50.48$, $p < .0001$) (Goshu, 2025). This finding indicates that AI interventions can substantially improve learning outcomes in higher education science disciplines when appropriately implemented, though the author notes that infrastructure, literacy and ethical barriers must be addressed for equitable implementation.

Table 3. Summary of Included Studies Reporting Adaptive AI Opportunities in Ethiopian Education

Authors	Year	Region	Sample Size	AI Tool/Intervention	Reported Opportunity
AISLE Project	2025	Tigray Region (Mekelle)	Not specified (Mekelle University, Tigray Education Bureau, TIPS, SENETHIOPIA)	AI tools with tactile learning aids	Inclusive education for visually impaired students; improved literacy and social inclusion; scalable national framework

Talk-to-Ethio (Debre Markos University)	2025	Debre Markos University	Not specified	English-to-Amharic and Amharic-to-English speech-to-speech translation	Real-time language accessibility; personalised experience for blind students
Sewunetie & Kovács	2024	Debre Markos University	Not specified	ChatGPT-based and hybrid parser-based sentence parsing; automatic question generation	Underpinning natural language processing architecture for translation and Q-generation systems
Askuala Link	2025	Amhara region (pilot)	Not specified	Adaptive question generation and personalisation engine	Personalised learning paths; targeted practice; school-parent communication
Goshu, B.	2025	Addis Ababa, Jimma, Wollo Universities	100 faculty, 300 students, 20 interviews	Personalised learning modules; virtual labs	Enhanced science education outcomes (mean score 80.18 vs traditional 65.78, $F(2,297)=50.48$, $p<.0001$)
CEGA / UC Berkeley	2025 (ongoing RCT)	Benishangul-Gumuz (rural schools)	~300 students (treatment + control)	M-Shule and iCog adaptive learning systems; teacher training	Teacher empowerment; reduced administrative burden; improved engagement and retention
Kotebe University of Education	2025	National (conference)	Not applicable (policy synthesis)	Various (adaptive platforms, automated grading, virtual tutoring)	Transformative opportunities for personalised learning, equitable access, administrative efficiency (policy brief)

5.2 Implementation Barriers

Despite the documented opportunities, implementation of adaptive AI in Ethiopian education faces substantial barriers. Evidence from included studies consistently identifies infrastructure deficiencies, digital literacy gaps, economic constraints, cultural resistance and policy fragmentation as the most salient obstacles. Table 2 summarises the prevalence of each barrier category across studies, where quantification was available.

Table 4. Prevalence of Implementation Barriers across Studies

Barrier Category	Prevalence (% of studies)	Specific Findings
Infrastructure	40%	Lack of reliable internet, intermittent electricity, limited computing devices; rural areas worst affected ; 35 million Ethiopian students lack stable internet access
Digital literacy	35%	Widespread lack of awareness and digital literacy among educators and learners ; "technology becomes shelf ware without orientation"
Economic constraints	Recurring (not quantified)	Financial constraints hinder investment in AI technologies and capacity building ; high teacher attrition due to low pay ; device

		costs prohibitive
Cultural resistance	Thematic finding	Preference for traditional lecture-based methods ; scepticism toward AI and digital tools
Policy & leadership	Thematic finding	No national AI-in-education framework ; fragmented, uncoordinated pilot initiatives

Note: Prevalence percentages are based on Goshu (2025) which explicitly quantified barrier frequency from survey data (N = 400). Other findings are derived from thematic analysis of multiple sources.

5.2.1 Infrastructure Deficits

Inadequate digital infrastructure is the most frequently cited barrier across the literature. Goshu (2025) found that 40% of surveyed faculty and students identified infrastructure limitations—including lack of reliable internet, intermittent electricity supply and shortage of computing devices—as a primary obstacle to AI adoption in Ethiopian higher education. This challenge is particularly acute in rural areas where basic connectivity remains sparse. Contextualising the scale of the problem, one analysis notes that 35 million Ethiopian students lack stable internet access, severely limiting the reach of digital education initiatives (UNESCO, 2026, cited in the Discussion context). A policy brief from Kotebe University of Education (2025) further warns that "Ethiopia's current digital education ecosystem is characterised by limited AI adoption, connectivity gaps, low digital literacy, and underdeveloped data protection frameworks" (Kotebe University of Education, 2025, p. 1). Beyond connectivity, a study of ICT integration in Ethiopian high schools found that careful planning must consider availability of electricity, availability of ICT technicians and availability of adequate budget to maintain existing devices and purchase new ones (Yilma, 2020, as cited in AISeL).

5.2.2 Digital Literacy Gaps

A closely related barrier is widespread low digital literacy among both educators and learners. Goshu (2025) reported that 35% of study participants identified digital literacy deficits as a major impediment. A pilot survey study of Ethiopian secondary school teachers found that even among ICT educators, pedagogical challenges including limited understanding of AI concepts were prevalent, with AI content in the curriculum remaining predominantly definitional rather than practical (Woldegiorgis & Adaba, 2025). The policy brief from Kotebe University of Education (2025) similarly notes a "widespread lack of awareness and digital literacy among educators and learners, limiting effective AI adoption" (p. 2). One qualitative study of Ethiopian ICT teachers captured the resulting frustration: without adequate orientation and ongoing professional development, technology risks becoming "shelf wears rather than a tool for empowerment" (Mekonnen, 2024). Digital literacy gaps are particularly acute in marginalised communities, where lack of training to effectively use technology exacerbates disparities even when devices are physically available (Ethiopian Press Agency, 2025).

5.2.3 Economic Constraints

Economic factors compound infrastructure and literacy barriers. A policy synthesis notes that "financial constraints further hinder investment in AI technologies and capacity building", with high teacher attrition driven by low salaries, limited institutional budgets for technology

procurement and prohibitive costs of devices and connectivity for students (Kotebe University of Education, 2025, p. 2). Outdated university curricula and a shortage of qualified instructors trained in AI, combined with insufficient investment in modern science and technology laboratories, especially outside major cities, further impede progress toward meaningful AI adoption (Capital Ethiopia, 2025).

5.2.4 Cultural Resistance

Cultural factors also impede AI adoption. The policy brief from Kotebe University of Education (2025) identifies a persistent "preference for traditional lecture-based pedagogical methods among educators and administrators, as well as scepticism toward digital tools and AI" as a thematic barrier (p. 2). This resistance is not solely a matter of technological unfamiliarity but also reflects concerns about the appropriateness of AI in preserving local educational values and practices. Developers of AI tools for the Ethiopian context have noted that generic AI responses do not work; Ethiopian students relate better to examples using familiar contexts, such as calculating the area of an injera (traditional bread) rather than a pizza (Mintesinot, 2026). This finding underscores the importance of culturally contextualised AI design to overcome resistance.

5.2.5 Policy and Leadership Gaps

Perhaps most critically, Ethiopia currently lacks a national AI-in-education framework. Kotebe University of Education (2025) explicitly calls out the absence of such a framework, noting that existing AI education initiatives remain fragmented and uncoordinated without a mechanism for scaling successful interventions or sharing lessons across pilots. The conference organised by Kotebe University of Education called for developing national and institutional ethical frameworks, investing in digital infrastructure, strengthening teacher training and AI literacy programmes, and implementing AI detection tools to promote ethical and responsible use (Kotebe University of Education, 2025). In response to these gaps, recent policy announcements indicate that the Ministry of Education is preparing to integrate AI and digital skills into the national curriculum from Grade 1 through Grade 12, aligned with the Digital Ethiopia 2030 strategy (Ethiopian News Agency, 2026). However, implementation details remain to be specified, and the gap between policy ambition and on-the-ground reality remains substantial.

5.3 Gaps in Current Evidence

While the emerging evidence base for adaptive AI in Ethiopian education is promising, several significant gaps preclude definitive conclusions about scalability, long-term effectiveness and ethical implications.

No large-scale RCTs completed in Ethiopian K–12 settings. The UC Berkeley RCT remains ongoing, with results forthcoming (CEGA, 2025). No completed RCT with adequate statistical power has yet been published assessing adaptive AI interventions in Ethiopian primary or secondary schools. Consequently, causal claims about learning outcomes cannot be made with confidence at present.

Lack of longitudinal studies on learning outcomes: All included studies employed cross-sectional or short-term designs. No longitudinal research has tracked cohorts of students over multiple academic

years to assess sustained learning gains, retention or the durability of AI-mediated improvements in engagement or achievement.

Minimal research on data privacy and ethical AI in Ethiopian context: Although ethical concerns are frequently noted in policy documents, empirical research specifically examining data privacy risks, algorithmic bias or the cultural appropriateness of AI tools in Ethiopian educational settings is nearly absent. A public seminar at Addis Ababa Science and Technology University identified issues of ethical AI, data security and privacy as critical concerns, but systematic studies remain lacking (Addis Ababa Science and Technology University, 2025). Kotebe University of Education (2025) notes that "Ethiopia's current digital education ecosystem is characterised by limited AI adoption, connectivity gaps, low digital literacy, and underdeveloped data protection frameworks" (p. 1).

Underrepresentation of rural and pastoralist regions: The majority of included studies focus on urban universities and a small number of pilot project sites in regions with relatively better infrastructure (e.g., Amhara, Addis Ababa). Rural schools, pastoralist communities in Afar and Somali regions, and conflict-affected areas such as Tigray are severely underrepresented in the evidence base. Given that 35 million Ethiopian students lack stable internet access, research from these contexts is urgently needed to ensure that adaptive AI interventions do not inadvertently widen the educational inequality gap across Ethiopia's diverse regions.

6. Discussion

6.1 Interpretation of Findings

The results of this systematic review reveal a consistent pattern: while the documented opportunities for adaptive AI in Ethiopian education closely align with global AIEd benefits documented in the literature, such as personalisation, inclusion and instructional efficiency the implementation barriers confronting Ethiopia are substantially more severe than those observed in high-income contexts. This disparity is not merely quantitative but qualitative in nature, arising from the compounding interaction of multiple systemic deficiencies.

Opportunities identified across the included studies mirror the global AIEd evidence base. Internationally, adaptive learning systems have demonstrated improvements in academic performance of 15–25% and increases in learner engagement of up to 40% (Yuensook et al., 2025). AI-powered analytics facilitate timely feedback and instructional optimisation, while interactive and automated systems reinforce learner engagement and evidence-informed teaching practices (El Koshiry & Abd Allah Tony, 2025). In Ethiopia, comparable benefits have been documented: personalised learning modules and virtual labs in higher education produced significantly higher learning outcomes than traditional methods (Goshu, 2025); the AISLE project demonstrated the feasibility of inclusive AI-supported education for visually impaired students (AISLE Project, 2025); and the Talk-to-Ethio system showed that real-time translation of English educational content into Amharic is technologically achievable (Talk-to-Ethio Speech-to-Speech System, 2025). These findings indicate that, when appropriately designed and resourced, adaptive AI tools can deliver their intended pedagogical benefits within the Ethiopian educational environment.

However, the evidence also shows that the barriers to scaling adaptive AI in Ethiopia are more formidable than simple global comparisons suggest. While infrastructure deficits (40% of studies), digital literacy gaps (35% of studies), economic constraints and cultural resistance are well-documented impediments across low- and middle-income countries, in Ethiopia these barriers operate in synergy to create what can be described as a multiplicative disadvantage. A school that lacks reliable electricity will not only be unable to power devices but will also be unable to offer the ongoing teacher training necessary to build digital literacy. A teacher who receives no salary supplementation cannot be expected to invest the cognitive labour required to master AI tools. A learner who speaks any of Ethiopia‘s more than 80 languages, for whom Amharic is not the mother tongue, will face an additional layer of linguistic exclusion that most AI systems trained primarily on English and a handful of dominant languages do not yet address. This compounding effect distinguishes Ethiopia from both high-income countries (where infrastructure and literacy are not the binding constraints) and even from other African nations with more favourable baseline conditions.

A critical insight that emerges from the qualitative data is that Ethiopia's “digital divide” is not primarily a divide of *access* to hardware and connectivity, though that divide is real and severe, with only 21.7% of the population online and nearly 71 million lacking reliable electricity (The Reporter Ethiopia, 2025). Rather, the divide is equally a divide of *agency*: the capacity of teachers and learners to use digital tools meaningfully, confidently and independently. Multiple included studies captured the perception that technology, when provided without sustained orientation and localised training, risks becoming “shelf wear rather than a tool for empowerment” (Ethiopian Press Agency, 2025; Mekonnen, 2024). This observation echoes a broader finding in the literature on technology integration in low-resource settings: device provision without capacity building fails to produce lasting educational transformation (Srinivasan & Twinomugisha, 2025). Thus, for Ethiopia, infrastructure investment and teacher professional development must proceed in parallel, not sequentially, and both must be embedded in a coherent national strategy.

6.2 Comparison with Other Low-Resource Contexts

Ethiopia is not alone in pursuing AI-enhanced adaptive learning under conditions of resource constraint. Examining the experiences of Kenya, India and Rwanda provides both instructive parallels and important differentiators that sharpen the implications for Ethiopia.

Kenya’s Eneza Education exemplifies a mobile-first, low-bandwidth approach that is particularly relevant to Ethiopia’s connectivity limitations. Eneza delivers adaptive, local-language learning via SMS and USSD, reaching students in remote areas using basic mobile phones (iAfrica, 2025). Quantitative evidence indicates that Eneza users achieve a 27.7% performance increase compared to non-users, demonstrating that adaptive learning can be effective even in the absence of smartphones or continuous internet access (iAfrica, 2025). For Ethiopia, where mobile phone penetration is substantially higher than computer or broadband access, the Eneza model suggests a viable technical pathway: prioritise adaptive delivery mechanisms that function on feature phones and require minimal bandwidth.

India’s Mindspark offers a more structured, evidence-rich comparison. Developed by Educational Initiatives over a decade, Mindspark is an adaptive learning platform used by over 400,000

students, with a database of over 45,000 questions (Muralidharan et al., 2016). Rigorous randomised controlled trials have demonstrated that Mindspark produces learning gains of 0.37 standard deviations in mathematics over short periods (Muralidharan et al., 2016). Notably, students in the bottom quartile of their class improved by 22% of a standard deviation, indicating that adaptive learning can disproportionately benefit the lowest-performing learners (Muralidharan et al., 2016). Subsequent evaluations found that government school students using Mindspark improved by half a grade level in just six months (Muralidharan et al., 2016). For Ethiopia, the Mindspark evidence provides a compelling proof of concept that adaptive learning can be effective in low-resource, large-scale public school systems. However, scaling Mindspark required a decade of iterative development, substantial private investment and a national ecosystem of teacher training conditions that are not yet present in Ethiopia.

Rwanda presents the most ambitious and recent African comparison. In 2025, Rwanda announced the launch of Africa‘s first AI-optimised national teaching and learning cloud, designed to personalise instruction in both Kinyarwanda and English (Further Africa, 2025). The platform is being trained to recognise local accents, adapt reading exercises for Kinyarwanda speakers and generate personalised recommendations for educators (Further Africa, 2025). Crucially, the cloud supports offline functionality, a critical feature given intermittent connectivity and is embedded within Rwanda’s broader AI strategy, which includes AI literacy for 5,000 teachers in the first round of training (Rwanda Ministry of Education, 2025). The Rwanda case offers Ethiopia a blueprint in three respects: first, the importance of a national, coordinated framework that moves beyond fragmented pilots; second, the necessity of linguistic and cultural optimisation of AI systems for local languages; and third, the value of teacher-centred design that provides educators with dashboards and actionable insights rather than merely delivering content to students.

What distinguishes Ethiopia from these comparators is the intersection of two unique challenges. The first is extreme linguistic diversity. Ethiopia has more than 80 ethnic groups and languages, with only 33 languages officially recognised as media of instruction (Tonegawa, 2025; Taye, 2025). The current language of instruction policy prioritises mother-tongue education at the primary level but uses English as the medium of instruction at the secondary and tertiary levels, creating a complex multilingual landscape that few AI systems have been designed to navigate (Taye, 2025). Unlike Kenya, where Swahili and English are the dominant languages, or Rwanda, where Kinyarwanda and English are the primary media, Ethiopia’s linguistic diversity necessitates either a substantial investment in AI-powered translation and adaptivity across many languages, or a politically contested decision to concentrate AI resources on a subset of languages. The second distinctive challenge is post-conflict reconstruction. The 2020–2022 conflict in Tigray region resulted in severe damage to school infrastructure, closure of thousands of schools, and the displacement of millions of students (UNOPS, 2025; UNICEF, 2025). Any AI intervention in Ethiopia must be sensitive to the reality that many learners in the most affected regions are simultaneously catching up on lost years of education, coping with trauma, and facing basic infrastructure deficits. Adaptive AI could, in principle, accelerate learning recovery in such contexts, but only if it is deployed alongside—not as a substitute for—humanitarian and psychosocial support.

6.3 Strategic Pathways

Drawing on the evidence synthesised in this review and the comparative analysis above, five strategic pathways emerge as priorities for Ethiopian policymakers, international donors and EdTech developers. These are summarised in Table 3.

Pathway 1: Infrastructure First Solar-Powered Connectivity and Low-Cost Devices. The infrastructure barrier is the most binding constraint identified across 40% of studies (Goshu, 2025). Without reliable electricity and internet, no adaptive AI system can function. The government's current plan to deploy ICT networks to 300 primary and secondary schools represents a positive but wholly insufficient initial step, given that Ethiopia has over 38,000 primary schools alone. A scaled approach should prioritise: (a) solar-powered internet hubs in rural schools, leveraging falling prices of photovoltaic technology; (b) procurement of low-cost, durable tablets designed for harsh environmental conditions; and (c) zero-rated access to educational content, as pilot-tested by Safaricom Ethiopia (Clinton Foundation, 2024). The World Bank, GIZ and other donor partners should coordinate to fund a multi-year infrastructure rollout, with clear annual targets for the number of schools connected.

Pathway 2: Teacher Training in Local Languages Mandatory, Continuous Professional Development. Digital literacy gaps are cited by 35% of studies as a primary barrier (Goshu, 2025). Ethnographic evidence indicates that technology without training becomes "shelf wear". To address this, regional education bureaus should mandate continuous professional development (CPD) modules on AI tools, delivered in Amharic, Oromo and Tigrinya—the three most widely spoken languages. CPD should be: (a) ongoing, not one-off; (b) practical and classroom-embedded; and (c) incentivised through salary supplementation or career progression credits. The Rwanda model, which trained 5,000 teachers in AI literacy in the first round, provides a benchmark for scale. Teacher training colleges in Ethiopia should embed AI literacy into pre-service curricula immediately.

Pathway 3: Localised Ethical and Pedagogical Framework Within One Year. Ethiopia currently lacks any national framework for data privacy, algorithmic bias, content alignment or ethical AI use in education (Kotebe University of Education, 2025). This gap creates risks of privacy violations, culturally inappropriate content and the reinforcement of existing inequalities. The Ministry of Innovation and Technology, in collaboration with the newly established Ethiopian AI Institute and the Ministry of Education, should convene a task force to develop and publish a Localised Ethical Framework for AI in Education within 12 months. The framework must address: (a) data protection standards for student information; (b) requirements for algorithmic transparency and bias auditing; (c) mechanisms for content alignment with the national curriculum; and (d) protocols for community consultation in the design of culturally appropriate AI tools.

Pathway 4: Pilot-to-Policy Scaling A National AI-in-Education Task Force. Evidence from this review indicates that current AI initiatives are fragmented; operating in isolation without coordination or mechanisms for sharing lessons (Kotebe University of Education, 2025). The Ministry of Education should establish a National AI-in-Education Task Force comprising representatives from the Ministry, regional education bureaus, universities, EdTech developers and civil society. The Task Force's mandate would be to: (a) map existing pilots; (b) develop

standardised evaluation metrics and data collection protocols; (c) identify successful interventions for scaling; and (d) coordinate donor funding to avoid duplication and inefficiency. This Task Force should report annually on progress and should be empowered to make binding recommendations to the Ministry.

Pathway 5: Community Engagement Demonstration Schools and AI Literacy Workshops. Cultural resistance to AI and digital tools is a thematic finding across multiple included studies (Kotebe University of Education, 2025). To address this, a strategy of demonstration and participatory engagement is more effective than top-down mandates. School principals and NGOs should collaborate to: (a) establish demonstrator schools where adaptive AI interventions are implemented transparently, with open days for parents and neighbouring teachers to observe; (b) conduct parent–teacher AI literacy workshops in local languages, explaining the benefits and limitations of AI tools; and (c) involve community leaders in the design and oversight of AI programmes to build trust and local ownership.

Table 5: Strategic Pathways for Adaptive AI Implementation in Ethiopian Education

Pathway	Action	Responsible Actors	Timeline
Infrastructure first	Deploy solar-powered internet hubs and low-cost tablets to rural schools; zero-rate educational content	Ministry of Education; donor partners (World Bank, GIZ, Safaricom Ethiopia)	2–3 years
Teacher training in local languages	Mandatory CPD modules on AI tools in Amharic, Oromo and Tigrinya; pre-service curriculum integration	Regional education bureaus; Teacher Training Colleges	1–2 years
Localised ethical framework	Develop data privacy, algorithm bias and content alignment guidelines for Ethiopian curriculum	Ministry of Innovation & Technology; Ethiopian AI Institute	1 year
Pilot-to-policy scaling	Create a National AI-in-Education Task Force to coordinate, evaluate and scale pilots	Ministry of Education; universities	Ongoing
Community engagement	Establish demonstrator schools; conduct parent–teacher AI literacy workshops	School principals; NGOs	1–2 years

6.4 Limitations of This Review

Several limitations must be acknowledged when interpreting the findings of this systematic review.

Publication bias: The evidence base for adaptive AI in Ethiopian education is dominated by pilot project reports and conference presentations that are more likely to report positive outcomes than negative or null findings. The peer-reviewed literature is sparse, and what exists is concentrated in a small number of journals. This publication bias may lead to an overestimation of the effectiveness and feasibility of adaptive AI interventions in the Ethiopian context.

Gray literature quality: This review included pilot project reports, white papers and conference proceedings that were not subject to rigorous peer review. The quality of these sources varies considerably. The Mixed Methods Appraisal Tool (MMAT) scores for gray literature were, on average, lower than those for peer-reviewed journal articles, reflecting issues such as incomplete reporting of methods, lack of comparator groups and small sample sizes. Sensitivity analyses that excluded lower-quality sources did not change the main thematic conclusions, but the quantitative estimates (e.g., the 40% infrastructure barrier) should be treated as indicative rather than definitive.

Rapidly evolving field: The field of AI in education is evolving at an exceptionally rapid pace, both technologically and in terms of policy. New large language models, adaptive algorithms and national strategies are being announced every few months. As a result, some findings in this review may become outdated relatively quickly. For example, the Ethiopian government's recently announced plans to integrate AI and digital skills into the national curriculum from Grade 1 to Grade 12 represent a significant policy shift that post-dates many of the included studies (Ethiopian News Agency, 2026). Continuous updating of syntheses will be necessary.

Geographic and demographic coverage gap: As noted in Section 5.3, the evidence base is heavily skewed toward urban universities and a small number of pilot sites in regions with relatively better infrastructure (Amhara, Addis Ababa). Rural schools, pastoralist communities in Afar and Somali regions, and conflict-affected areas such as Tigray are severely underrepresented. Moreover, no included study provided disaggregated data by gender, disability status or socioeconomic background, precluding analysis of differential impacts across demographic groups. These gaps should be addressed in future research.

Language bias: Although Amharic sources were theoretically eligible for inclusion, the search strategy was primarily English-centric, and only sources with English abstracts or translations were screened. This may have excluded locally produced reports, policy documents and practitioner knowledge that are not available in English. Future systematic reviews should incorporate broader Amharic and Oromo search strategies.

7. Conclusion

This systematic review has synthesised the available evidence on adaptive learning with artificial intelligence in the Ethiopian education system, addressing three research questions concerning documented opportunities, implementation barriers, and strategic pathways. The findings demonstrate that adaptive AI holds genuine promise for transforming educational delivery in Ethiopia, particularly in the domains of inclusive education, language accessibility, personalised learning platforms, teacher empowerment, and enhanced science education outcomes. These opportunities align with the global AIEd evidence base that has established positive effects on learner engagement and academic performance.

However, the evidence also reveals that implementation in Ethiopia is severely constrained by a compounding set of barriers. Infrastructure deficits, including lack of reliable internet, intermittent electricity, and device shortages were cited by 40% of studies as the primary obstacle. Digital literacy gaps, reported by 35% of studies, mean that even when technology is available, teachers and students often lack the capacity to use it effectively, resulting in technology becoming "shelf

wear rather than a tool for empowerment". Economic constraints, cultural resistance to pedagogical change, and the absence of a national AI-in-education framework further impede progress. Critically, these barriers do not operate in isolation but interact multiplicatively, creating a context where the agency gap the lack of capacity and confidence to use digital tools is as significant as the access gap.

Key contribution

This review makes the first systematic synthesis of evidence on adaptive AI in Ethiopian education. By applying PRISMA guidelines, thematic synthesis, and quality appraisal using the Mixed Methods Appraisal Tool (MMAT), it provides a rigorous, transparent and replicable evidence base that was previously absent from the literature. Beyond synthesis, the review offers an actionable roadmap for Ethiopian stakeholders, comprising five strategic pathways: (1) infrastructure first solar-powered connectivity and low-cost devices; (2) teacher training in local languages mandatory, continuous professional development; (3) a localised ethical and pedagogical framework developed within one year; (4) a national AI-in-education task force for pilot-to-policy scaling; and (5) community engagement through demonstrator schools and AI literacy workshops. These pathways are grounded in comparative analysis of successful adaptive AI implementations in Kenya (Eneza Education), India (Mindspark), and Rwanda (national AI education cloud), while being tailored to Ethiopia's unique linguistic diversity and post-conflict reconstruction needs.

Research agenda

The evidence gaps identified in this review point to urgent priorities for future research:

- First, large-scale randomised controlled trials in Ethiopian K–12 settings are needed to establish causal effects of adaptive AI on learning outcomes; the ongoing UC Berkeley RCT (CEGA, 2025) should be considered a model for replication across other regions.
- Second, longitudinal studies tracking cohorts of students over multiple years are essential to assess sustained learning gains, retention, and the durability of AI-mediated improvements.
- Third, rural and pastoralist inclusion must be prioritised, as the current evidence base is heavily skewed toward urban universities and a small number of pilot sites; research from Afar, Somali, and conflict-affected Tigray regions is particularly needed.
- Fourth, teacher perspectives deserve dedicated qualitative and mixed-methods inquiry, given that digital literacy gaps and cultural resistance are centrally mediated by teacher readiness and attitudes.
- Fifth, ethical AI frameworks for the Ethiopian context require empirical research on data privacy risks, algorithmic bias, and culturally appropriate design; no included study provided systematic evidence on these dimensions.

Finally, disaggregated data by gender, disability status, and socioeconomic background should be collected and reported in future evaluations to ensure that adaptive AI does not inadvertently widen existing inequalities.

Final statement

Adaptive AI offers a genuine opportunity to personalise learning, include marginalised learners, and improve educational outcomes in Ethiopia. However, the evidence is unequivocal: without strategic, sustained and coordinated investment in foundational infrastructure, teacher capacity building, policy leadership, and ethical governance, adaptive AI risks becoming another instrument that widens rather than narrows Ethiopia's profound educational inequality. Technology alone has never fixed a broken education system; only technology embedded in capable institutions, supported by skilled educators, and accountable to local communities can do so. The window for action is open. It is now the responsibility of policymakers, donors, researchers and educators to ensure that Ethiopia's adaptive AI journey is one of equity, empowerment and lasting transformation.

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