Smart Classroom Technologies in Tanzanian Secondary Schools: Enabling Factors, Barriers, and Educational Outcomes

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ABSTRACT

The integration of smart classroom technologies in secondary education has gained momentum across Sub-Saharan Africa, yet Tanzania's experience remains fragmented across dispersed studies that have rarely been synthesised. This narrative review synthesises evidence on the enabling factors, barriers, and educational outcomes of smart classroom technologies in Tanzanian secondary schools, situating local evidence within the wider Sub-Saharan African and global literature. A systematic search of electronic databases and grey literature sources identified 44 relevant articles published between 2011 and 2026, which were screened against three research questions and synthesised thematically. The review finds that enabling factors include technological infrastructure, sustained teacher professional development, institutional support, and learner-side capacities such as digital self-efficacy, with mobile first and low cost solutions proving especially adaptive to Tanzanian conditions. Barriers converge on financial constraints, unreliable electricity and connectivity, inadequate technical support, teacher digital literacy gaps, socio cultural resistance, and policy implementation deficits. Educational outcome evidence, though still dominated by perception based Tanzanian studies, is anchored by regional causal evidence showing significant gains in mathematics and science, dose response effects with sustained exposure, and global meta analytic evidence of large positive effects on cognitive and behavioral outcomes. The review concludes that technology amplifies, rather than replaces, effective pedagogy, and recommends strategic infrastructure investment, pedagogically grounded teacher training, and rigorous longitudinal evaluation of Tanzanian smart classroom initiatives.

Keywords: Smart Classroom Technologies, Enabling Factors, Barriers, Educational outcomes, Narrative review.

INTRODUCTION

Background

The rapid digitisation of education has given rise to the smart classroom, an instructional environment in which networked hardware, intelligent software and data driven services converge to support teaching and learning. Although definitions vary, the literature converges on a four facet taxonomy comprising smart content, smart interaction and engagement, smart assessment, and a smart physical environment (Saini & Goel, 2019). Li et al. (2015) operationalised this environment through a validated ten factor Smart Classroom Inventory spanning physical design, flexibility, technology usage, learning data capture, differentiation, investigation, cooperation, student cohesiveness, equity, and learning experience. More recent taxonomies extend the scope to adaptive learning systems, learning analytics, immersive virtual and augmented reality, gamification, assistive and multilingual tools, Internet of Things (IoT) sensing, and artificial intelligence (AI) driven personalisation (Dimitriadou & Lanitis, 2023; Moses & Sadiq, 2026; OECD, 2021). The OECD (2021) frames such technologies adaptive learning platforms, classroom analytics, engagement sensing, and game based assessment as frontiers capable of personalising instruction and widening equity, while simultaneously cautioning that technology amplifies good or bad pedagogy rather than substituting for it.

In developing countries, and particularly in Sub-Saharan Africa (SSA), smart classroom technologies carry amplified significance. Educational systems in the region contend with teacher shortages, overcrowded

classrooms, resource deficits, and curricula under pressure from high stakes examinations (Tikly et al., 2018). Proponents argue that digital tools can bridge these gaps by expanding access to quality materials, supporting learner-centred pedagogy, and developing the digital skills required for participation in the Fourth Industrial Revolution (Fomunyam, 2019; Makinde et al., 2024; Oosthuizen & Motsatsi, 2025). Cross national analyses nonetheless show that only about 29% of SSA schools have electricity, 6% have internet access, and 14% have computers (Langthaler & Bazafkan, 2020), meaning that the promise of smart classrooms is conditioned by profound structural constraints. Reviews of technology for education initiatives in low income countries similarly warn that device only deployments without content, teacher preparation, and maintenance systems consistently fail to produce learning gains (Wagner, 2016).

Tanzania exemplifies this dual reality. The country has pursued technology integration through policies such as the 2007 Information and Communication Technology (ICT) policy, the Education Sector Development Programme, and the national ICT curriculum, alongside flagship interventions including the BridgeIT (Elimu kwa Teknolojia) mobile learning project in 150 schools reaching over 60,000 learners, the ISPACES innovation framework, the Language Supportive Teaching and Textbooks (LSTT) project, and the Shule Direct digital platform (Gardner et al., 2018; Tikly et al., 2018). Empirical studies from Dar es Salaam, Morogoro, Mbeya, Dodoma, Mtwara, Kigoma, and Arusha document teachers and students using multimedia content, learning management systems, mobile phones, interactive whiteboards, school information systems, and, most recently, generative AI tools (Kamaghe, 2026; Komba et al., 2025; Mubofu & Adoph, 2026; Nsyengula et al., 2025). Yet Tanzanian evidence remains scattered across dissertations, journal articles, and policy reviews, and has rarely been synthesised against a coherent conceptual frame. This narrative review addresses that gap.

Significance of the Tanzanian Context

Tanzania's secondary education system is one of the largest in East Africa, and its experience with classroom technology instructs the wider region in at least three ways. First, Tanzania is among the most frequently studied countries in SSA wide reviews of mobile and smart learning in secondary schools, tied with South Africa as the leading contributor of primary studies (Mabalane, 2025). Second, Tanzanian programmes such as BridgeIT have been exported as models to other countries, making the local evidence base consequential beyond national borders (Gardner et al., 2018). Third, findings from neighbouring Rwanda where national smart classroom and one laptop per child programmes have been evaluated with large samples and quasi experimental designs are highly transferable to Tanzania's linguistic, infrastructural, and institutional conditions (Nsabimana et al., 2024; Turinumukiza et al., 2025, 2026). Understanding what enables, obstructs, and results from smart classroom technologies in Tanzanian secondary schools is therefore both a national policy priority and a regional research imperative.

Objectives of the Review

This narrative review synthesises the existing literature to analyse three research objectives; (1) Factors enable the adoption and effective use of smart classroom technologies in Tanzanian secondary schools (2) Barriers impede the adoption and effective use of these technologies (3) Influence of smart classroom technologies have on educational outcomes By mapping empirical and conceptual evidence from Tanzania and transferable SSA and global sources onto these objectives, the review aims to consolidate an evidence base that can inform government, school level, and development partner decision making, and to identify priorities for future research.

METHODOLOGY

Literature Search Strategy

A comprehensive literature search was conducted across electronic databases and repositories including Google Scholar, ERIC, Scopus, JSTOR, the African Journals Online (AJOL) platform, and institutional repositories of Tanzanian universities, complemented by grey literature from organisations such as UNU-WIDER, the World Bank, and the OECD. Search terms combined technology descriptors ("smart classroom,"

"smart learning environment," "educational technology," "ICT integration," "mobile learning," "artificial intelligence in education," "interactive whiteboard," "learning management system") with context descriptors ("Tanzania," "Tanzanian secondary schools," "Sub-Saharan Africa") and outcome descriptors ("enabling factors," "barriers," "challenges," "educational outcomes," "academic performance," "student engagement"). The search covered publications from 2011 to 2026, a window that captures the post BridgeIT era of Tanzanian educational technology while including the seminal global conceptualizations of smart classrooms.

The search was executed between 12 January 2026 and 27 February 2026, with a final update search completed on 20 March 2026; all sources were searched within the same window so that the procedure is fully reproducible. Search strings were adapted to the syntax of each database, and the number of records retrieved from every source was logged at the point of search, as summarized in the table below (total n = 318).

Search Sources, Database-Specific Search Strings, and Records Retrieved

Source	Database-specific search string	Records retrieved
Google Scholar	"smart classroom" OR "smart learning environment" OR "mobile learning" OR "ICT integration" AND "Tanzania" AND "secondary school" (first 200 hits sorted by relevance screened)	146
Scopus	TITLE-ABS-KEY ("smart classroom" OR "smart learning environment" OR "educational technology*" OR "ICT integration" OR "mobile learning" OR "artificial intelligence in education" OR "interactive whiteboard" OR "learning management system") AND ("Tanzania*" OR "Sub-Saharan Africa") AND ("secondary school*" OR "enabling factor*" OR barrier* OR "educational outcome*" OR "academic performance") AND PUBYEAR > 2010	58
ERIC (EBSCOhost)	("smart classroom" OR "smart learning environment" OR "educational technology" OR "mobile learning" OR "ICT integration") AND (Tanzania OR "Sub-Saharan Africa') AND ("secondary school" OR "academic performance" OR barriers)	39
African Journals Online (AJOL)	("smart classroom" OR "ICT integration" OR "educational technology") AND "Tanzania" AND "secondary school"	31
JSTOR	("smart classroom" OR "educational technology" OR "mobile learning") AND ("Tanzania" OR "Sub-Saharan Africa")	19
Tanzanian institutional repositories (UDSM, Mzumbe, OUT, NM-AIST)	("ICT" OR "smart classroom" OR "technology") AND "secondary schools" AND "Tanzania"	16
Grey literature (UNU-WIDER, World Bank, OECD)	("smart classroom" OR "technology in education") AND ("Rwanda "OR "Tanzania" OR "Sub-Saharan Africa")	9
Total records identified		**318**

Inclusion and Exclusion Criteria

Studies were included if they (a) addressed smart classroom technologies or closely related digital learning tools (multimedia content, mobile learning, interactive whiteboards, LMS, school information systems, AI and IoT applications), (b) focused on primary or secondary education, or on teacher professional development for school level instruction, (c) reported empirical data (quantitative, qualitative, or mixed methods) or authoritative conceptual and policy analysis, (d) were published in English in peer reviewed journals, academic

dissertations, or recognized working paper series and (e) provided evidence relevant to at least one of the three research questions. Because the Tanzanian primary evidence base is thin, studies from Rwanda, Nigeria, Kenya, Botswana, The Gambia, and SSA wide reviews were included where their contexts and designs permitted justified transfer to Tanzanian secondary schools, consistent with narrative review practice. Global meta analyses and technical reviews were retained as definitional and benchmark anchors. Studies confined to higher education without school level transfer value, adult and non-formal education, and individual chapters within edited volumes unrelated to the research questions were excluded or used as background only.

Inclusion and Exclusion Criteria for Study Selection

Criterion (PICOS-adapted domain)	Inclusion Criteria	Exclusion Criteria
Population / Educational level	Primary or secondary education; teacher professional development for school level instruction.	Higher education without school level transfer value; adult and non-formal education.
Topic / Intervention	Smart classroom technologies or closely related digital learning tools (multimedia content, mobile learning, interactive whiteboards, learning management systems, school information systems, AI and IoT applications).	Studies not addressing smart classroom technologies or the three research questions.
Context	Tanzania; studies from Rwanda, Nigeria, Kenya, Botswana, and The Gambia, and SSA-wide reviews where contextual similarity permits justified transfer to Tanzanian secondary schools; global meta-analyses retained as definitional and benchmark anchors.	Contexts without justified transferability to Tanzanian secondary schools.
Outcomes / Relevance	Evidence relevant to at least one of the three research questions (enabling factors, barriers, educational outcomes).	No evidence relevant to any of the three research questions.
Study design	Empirical studies (quantitative, qualitative, or mixed methods) or authoritative conceptual and policy analysis.	
Publication type	Peer-reviewed journals, academic dissertations, or recognised working paper series.	Individual chapters within edited volumes unrelated to the research questions (used as background only).
Language and timeframe	English-language publications from 2011 to 2026.	Non-English publications; published before 2011.

Note. Adapted from the PICOS-framed eligibility criteria applied in the accompanying systematic literature review (Population, Intervention, Context, Outcomes, Study Design).

Data Extraction and Analysis

Each identified article was screened against the three research questions and rated as highly relevant, partially relevant, or of low or background relevance, using a structured filtering matrix that recorded context, level of education, design, and the specific evidence contributed to each question. This process was conducted

iteratively across six screening batches, yielding a final corpus of 44 articles; 24 with direct Tanzania based evidence and 20 contextual or global sources. Following PRISMA style screening logic, records were deduplicated, screened by title and abstract, and assessed in full text, with companion papers by the same authors treated as single evidence sources to avoid double counting. Data were then extracted verbatim where possible and synthesised narratively, organising the evidence thematically under enabling factors, barriers, and educational outcomes. Where outcomes evidence from outside Tanzania was used, transferability is explicitly argued rather than assumed. The review's reliance on published sources and its narrative (rather than meta analytic) synthesis are acknowledged as limitations in Section 6.3.

Screening proceeded in three documented stages. First, the 318 records were deduplicated using reference management software followed by manual checking, leaving 210 unique records. Second, titles and abstracts were screened against the inclusion and exclusion criteria; 132 records that clearly failed the criteria were excluded, and 78 reports were sought for full-text retrieval, of which 6 could not be retrieved, leaving 72 full-text reports assessed for eligibility. Third, 28 reports were excluded at the full-text stage for documented reasons; higher education focus without school level transfer value (n = 9), not addressing smart classroom technologies (n = 4), no evidence relevant to the three research questions (n = 5), context not transferable to Tanzanian secondary schools (n = 8), and companion papers of already included studies (n = 2), yielding the final corpus of 44 studies (Figure 1). All screening decisions and reasons for exclusion were recorded in a screening log to ensure an auditable trail. Throughout Sections 3 to 5, evidence is attributed explicitly by country, findings from Tanzanian studies are reported as the primary evidence base, while evidence from Rwanda, Nigeria, The Gambia, Botswana, and other settings is presented separately as transferred evidence whose applicability to Tanzanian secondary schools is argued rather than assumed. References cited beyond the 44 study corpus served definitional, conceptual, or background functions and were not part of the synthesis.

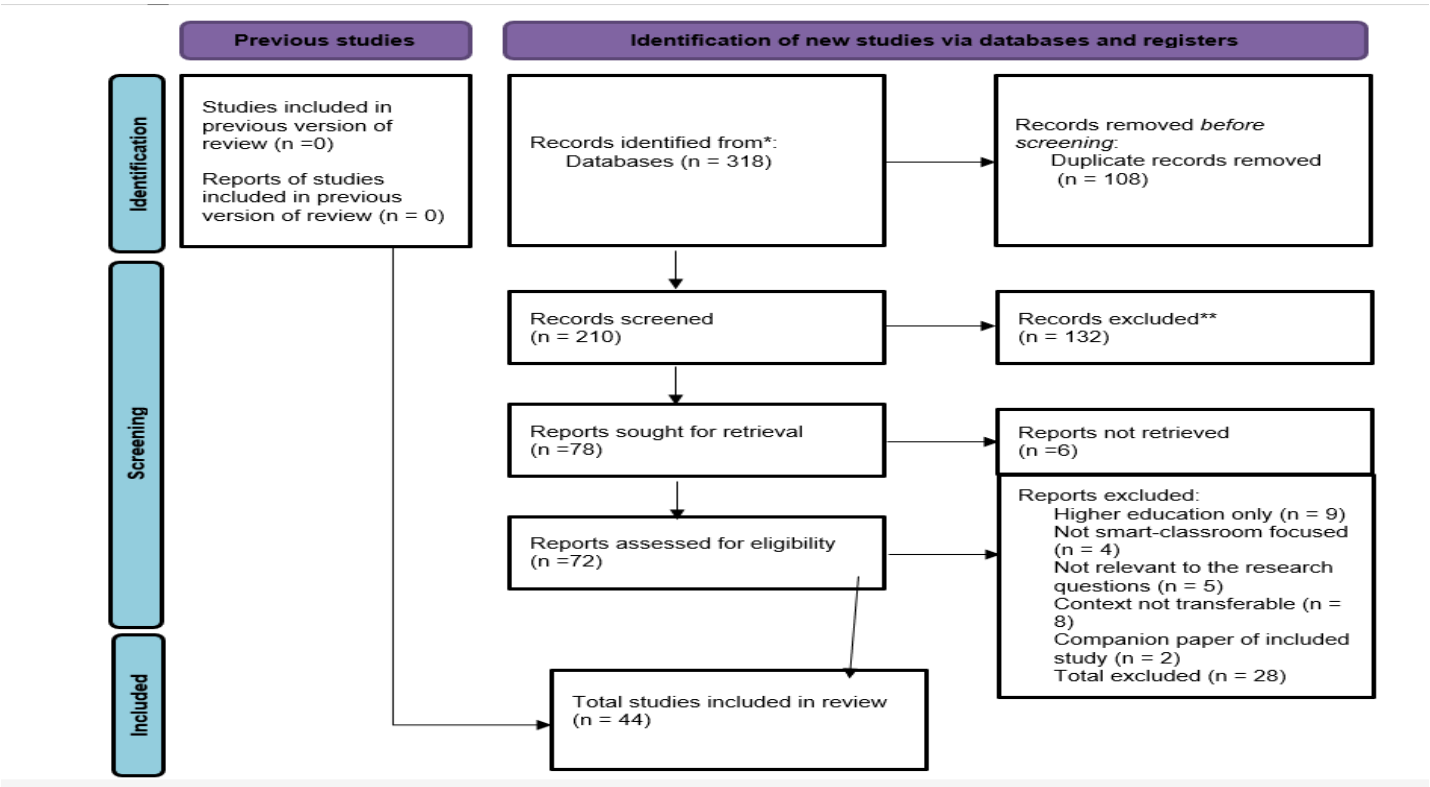

Figure 1. PRISMA 2020 flow diagram (Page et al., 2021) of the identification, screening, and inclusion of studies.

Quality Appraisal and Characteristics of Included Studies

The methodological quality of the 44 included studies was appraised using an adapted weight of evidence framework (Gough, 2007), which judges each source on three dimensions; (a) methodological quality, that is, the adequacy of the research design, sampling, and analysis for the claims made, (b) relevance, that is, the

directness of the evidence to the three research questions and (c) contextual transferability, that is, the degree to which findings from non-Tanzanian settings could be justified for Tanzanian secondary schools. Each study was rated high, moderate, or low on each dimension. Quasi experimental and large scale studies (Blimpo et al., 2020; Nsabimana et al., 2024) were weighted most heavily in the synthesis, survey and perception based Tanzanian studies were weighted as moderate and are explicitly identified as perception based where cited, conceptual and policy papers were used for framing rather than as outcome evidence. No study was excluded solely on quality grounds, given the thin Tanzanian evidence base, but the strength of the conclusions reflects these weightings, and the predominance of perception based local evidence is acknowledged as a limitation in Section 6.3. The table below summaries the characteristics of the 44 included studies.

Characteristics of the 44 Included Studies

No.	Author(s) and Year	Country/ Context	Educational Level	Research Design	Sample/Data Source	Principal Findings
1	Daudi & Nzilano (2019)	Tanzania (Ilala, Dar es Salaam)	Secondary	Survey (quantitative)	Secondary school students	Students skilled in ICT obtained better grades; positive attitudes linked to performance intentions.
2	Joseph (2021)	Tanzania (Mikindani, Mtwara)	Secondary	Mixed methods	Selected secondary schools	60% of teachers lacked technical support; computers and projectors enable instruction where available.
3	Joyce-Gibbons et al. (2018)	Tanzania	Secondary	Mixed methods	Two secondary schools	Mobile phones support curriculum aligned learning but raise distraction concerns.
4	Kamaghe (2026)	Tanzania (Dar es Salaam, Dodoma)	Secondary (teachers)	Survey	Teachers using generative AI	Generative AI perceived as easy to use and time-saving; workload-reduction scores rose from 2.2 to 4.0 on a five-point scale.
5	Kihoza (2016)	Tanzania	Secondary	Design-based PhD study	Secondary schools	Absence of a national ICT integration framework a primary obstacle; blended learning framework targets the 4Cs.
6	Kihoza et al. (2016)	Tanzania	Secondary	Survey	Secondary school teachers/tutors	Teachers ready to use blended learning resources but require sustained capacity building; only 44% active ICT users.
7	Komba et al. (2025)	Tanzania (Mbeya)	Secondary	Qualitative case study	Mbeya City Council schools	Google Classroom users outperformed non-users; rural schools report one computer for the entire school.
8	Luchagula (2025)	Tanzania (Kigoma)	Secondary	Survey (MA dissertation)	Public secondary school teachers	76% of teachers perceived school information system infrastructure as adequate.
9	Mafang'ha (2016)	Tanzania (Ilala, Dar es Salaam)	Secondary	Mixed methods (MA dissertation)	Secondary school teachers	80% cited lack of technical support; 88% cited negative attitudes as limiting ICT use.
10	Manyama & Ndibalema (2017)	Tanzania (Dodoma)	Secondary	Survey	Government secondary school teachers	WhatsApp and social networks support professional development; generational gaps in acceptance.
11	Mfaume	Tanzania	Secondary	Survey	Secondary school	Majority of teachers and

	(2019)				teachers	students own mobile phones, enabling mobile-first learning.
12	Mnyawami et al. (2022)	Tanzania (national)	Secondary	Machine learning (Auto ML)	206,885 national student records	Student dropout predicted with up to 99.8% accuracy, enabling early intervention.
13	Mtebe et al. (2016)	Tanzania (nationwide)	Secondary	Survey	1,137 science and mathematics teachers	Facilitating conditions and motivation predicted multimedia use; ten-day training insufficient.
14	Mubofu & Adoph (2026)	Tanzania (Dar es Salaam)	Secondary	Survey (quantitative)	Secondary school teachers	Training significantly associated with curriculum-integrated use of open educational resources; policy guidance unclear.
15	Ngodu et al. (2024)	Tanzania	Secondary (science)	Mixed methods	Science teachers and schools	Capacity building rated the highest context-relevant ICT integration strategy.
16	Nsyengula et al. (2025)	Tanzania (Mbeya and other regions)	Secondary	Mixed methods	Language-learning classrooms	Tablets and whiteboards valued for interactivity; donated tablets left idle for want of training.
17	Peter (2023)	Tanzania	Secondary	Design-based PhD thesis	Secondary schools	E-pedagogy model built on games, gamification and role play; governance gaps constrain adoption.
18	Senyagwa (2020)	Tanzania (Mvomero, Morogoro)	Secondary	Comparative mixed methods (MA dissertation)	Selected secondary schools	Teachers associated ICT-supported lessons with better student performance and understanding.
19	Warioba (2020)	Tanzania (Serengeti)	Secondary	Mixed methods (MA dissertation)	Community secondary schools	ICT reported to facilitate academic performance, save time and enhance interaction.
20	Gardner et al. (2018)	SSA incl. Tanzania	Secondary	Policy/programme review	BridgeIT and SSA programme documents	BridgeIT reached 150 schools and over 60,000 learners; cascade training supports scale.
21	Kizilcec et al. (2021)	SSA incl. Tanzania	School-age children	Mixed methods	Mobile learning during school disruptions	Gendered gaps in phone ownership and parental obligations limit access even where services are free.
22	Langthaler & Bazafkan (2020)	SSA incl. Tanzania	System level	Policy analysis	SSA-wide statistics and debate	Only about 29% of SSA schools have electricity, 6% internet, 14% computers; governance decisive for equity.
23	Mabalane (2025)	SSA incl. Tanzania	Senior secondary	Systematic review (FRAME model)	SSA mobile-learning studies	Teacher digital literacy gaps the single most cited challenge (54%); Tanzania a leading contributor of studies.
24	Tikly et al. (2018)	SSA incl. Tanzania	Secondary	Policy review	STEM education programmes	English-language dominance of content disadvantages learners; structured teacher development essential.
25	Akomolehin & Aluko	SSA cross-	System level	Cross-regional	E-learning access and quality data	Last-mile connectivity, device distribution and solar power

	(2025)	regional		analysis		distinguish regional leaders from laggards.
26	Bello Mubarak & Adekola Kamaldeen (2026)	Nigeria	Junior secondary	Systematic literature review	Public secondary schools	Rural schools average 81 students per computer; gamified instruction improved motivation and concept mastery.
27	Blimpo et al. (2020)	The Gambia	Secondary	Quasi-experimental	National examination records	Interactive whiteboard programme: +0.59 SD in mathematics; 15-percentage-point rise in credit in mathematics and English.
28	Chen & Liu (2024)	Global	Primary/secondary	Meta-analysis	21 empirical studies	Large cognitive (SMD = 1.014) and behavioural (SMD = 2.155) effects; near-zero affective effects.
29	Manny-Ikan et al. (2011)	Israel	Middle/senior high	Mixed-methods evaluation	SMART CLASSROOM pilot schools	IWBs raised enjoyment, interest and participation; operational-only training produces "digital chalkboard" use; engagement halo decays.
30	Malik & Shanwal (2017)	India	Grade 8	Quasi-experimental	Smart vs traditional classrooms	Smart classroom instruction showed significant post-test achievement advantage.
31	Ngendahayo et al. (2024)	Rwanda	A-level STEM	Structural modelling	Secondary STEM learners	Learner satisfaction predicted academic performance; technology self-efficacy the prerequisite driver; gender gap in ease of use.
32	Nsabimana et al. (2024)	Rwanda	Lower secondary	Quasi-experimental (staggered rollout)	318,643 students	Gains of 0.002–0.004 SD per month of exposure; effects near zero before ten months; larger for girls.
33	Nshunguyimana et al. (2025)	Rwanda (Gakenke)	Secondary	Survey/correlational	Secondary school students	Type of digital resource accessed predicted academic performance; 82.9% agreed digital resources improve grades.
34	Odezue et al. (2026)	Nigeria (Nsukka)	Secondary	Survey	English language teachers	High utilisation of projectors, PowerPoint and videos; low utilisation of advanced platforms.
35	OECD (2021)	Global	System level	Policy report/analysis	PISA and policy data	Technology amplifies rather than replaces pedagogy; use intensity alone negatively associated with performance.
36	Ogunwale (2025)	Africa (incl. Nigeria)	School level	Systematic review	AI-in-education deployments	Adaptive platforms produced 23% test-score gains and 15% dropout reduction; 34% of girls vs 62% of boys own devices.
37	Saini & Goel (2019)	Global	All levels	State-of-the-art review	Smart classroom literature	Four-facet smart classroom taxonomy; fully equipped smart classrooms 'exorbitant' for developing countries.
38	Sani et al. (2026)	Nigeria (Gombe)	Senior secondary	Mixed methods	Public senior secondary schools	Infrastructure adequacy determines integration level; schools without AI budgets

						default to teacher-centred methods.
39	Tsayang et al. (2020)	Botswana	Secondary	Survey	SMART boards pilot students	78% reported moderate-to-high motivation; 72% reported better performance in subjects using smart boards.
40	Turinumukiza et al. (2025)	Rwanda (Gicumbi)	Secondary	Regression modelling	Rural public secondary schools	Pedagogical readiness, infrastructure and institutional support the strongest predictors of smart classroom utilisation.
41	Turinumukiza et al. (2026a)	Rwanda (Gicumbi)	Secondary	Mixed methods	Rural secondary schools	54.3% rarely had technical support; smart classrooms often function as 'projection spaces'.
42	Turinumukiza et al. (2026b)	Rwanda	Secondary	Mixed methods	Smart classroom lessons	Engagement strongly correlated with collaboration and critical thinking; highest under peer interaction.
43	Xing & Lu (2022)	China	Secondary	Survey/structural modelling	Secondary school students	Internet self-efficacy, use and attitude explained 28.4% of computational thinking variance.
44	Zhang & Li (2021)	China	All levels	System design study	IoT-based smart classroom	IoT sensing supports data-driven personalisation with 99.9% data transmission reliability.

Note. The 44 studies comprise 19 Tanzania-specific studies, 5 Sub-Saharan African multi country studies or reviews containing substantial Tanzanian data, and 20 regional (Rwanda, Nigeria, The Gambia, Botswana) and global sources retained for transferability and benchmarking, consistent with the 24 Tanzanian evidence and 20 contextual or global sources reported in Section 2.3. Sources cited elsewhere in the review for definitional, conceptual, or background purposes (Li et al., 2015; Lui & Slotta, 2014; Mogas et al., 2022; Tissenbaum & Slotta, 2019) were not part of the synthesis corpus.

Enabling Factors for Smart Classroom Technologies

Infrastructure and Resources

The availability of technological infrastructure constitutes the most fundamental enabling condition, and its absence is repeatedly identified as the binding constraint in Tanzanian schools. Studies from Morogoro, Dar es Salaam, Serengeti, and Mbeya document computers, projectors, laboratories, and internet connections where available as direct enablers of technology supported instruction (Joseph, 2021; Komba et al., 2025; Senyagwa, 2020; Warioba, 2020). Luchagula (2025) found that 76% of teachers in Kigoma agreed that technological infrastructure in their schools was adequate, and perceived infrastructure adequacy has been shown to significantly determine the level of technology integration (Sani et al., 2026). Rwanda's national experience demonstrates what sustained public investment can achieve, every school in the national smart classroom programme received 50 laptops, a projector, and internet access under a roughly US$310 million annual ICT in education commitment, and the type of digital resource accessed significantly predicted academic performance (Nshunguyimana et al., 2025; Nsabimana et al., 2024). Akomolehin and Aluko (2025) identify last mile connectivity investment, device distribution, and solar powered rural connectivity as the policy levers distinguishing regional leaders from laggards.

Equally important is the form infrastructure takes. Low cost, resilient technologies have proven especially enabling in resource constrained Tanzanian settings. Mobile phones, owned by the majority of teachers and students, support WhatsApp teacher networks, GeoGebra and Quizizz mathematics applications, and curriculum aligned multimedia delivery (Joyce et al., 2018; Mabalane, 2025; Mfaume, 2019; Manyama & Ndibalema, 2017). Offline capable designs downloadable modules, DVDs, and solar powered classrooms sustain continuity where electricity and connectivity are unreliable (Blimpo et al., 2020; Kihoza et al., 2016;

Ogunwale, 2025). At the frontier, AI and IoT applications are emerging as enablers, IoT sensing of temperature, light, and attendance supports data driven personalization with 99.9% data transmission reliability (Perfectson et al., 2025; Zhang & Li, 2021), adaptive platforms, intelligent tutoring systems, and multilingual chatbots such as Tanzania's UmojaAI personalise pace and language of instruction (Mugoniwa, 2026; Ogunwale, 2025) and generative AI tools have been found easy to use and time saving by Dar es Salaam and Dodoma teachers, with perceived usefulness driving adoption (Kamaghe, 2026; Odezue et al., 2026). Machine learning models using national assessment data now enable early identification of dropout risk, an indirect but measurable educational outcome of smart education infrastructure (Mnyawami et al., 2022).

Teacher Training and Professional Development

Technology delivers educational value only when teachers can integrate it pedagogically, and the corpus is unequivocal that training is the decisive enabling factor. Mtebe et al. (2016), in a nationwide study of 1,137 Tanzanian science and mathematics teachers, found that facilitating conditions and hedonic motivation predicted multimedia use, while a mere ten-day training was insufficient to overcome effort expectancy barriers. Kihoza et al. (2016) reported that teachers expressed readiness to use blended learning resources but required sustained capacity building, with only 44% of tutors' active ICT users. Mubofu and Adoph (2026) established a statistically significant association between training and the curriculum integrated use of open educational resources among Dar es Salaam teachers, and Ngodu et al. (2024) identified capacity building as the highest rated context relevant strategy for science subjects. Professional learning communities WhatsApp subject groups, online communities of practice, and cascade training models in which trained teachers instruct subsequent cohorts provide scalable, low cost formats that suit Tanzanian conditions (Blimpo et al., 2020; Gardner et al., 2018; Manyama & Ndibalema, 2017).

The content of training matters as much as its occurrence. Reviews of interactive whiteboard implementations warn that operational training without pedagogical grounding produces "digital chalkboard" use that reinforces frontal teaching (Manny-Ikan et al., 2011), while the TPACK framework demonstrates that technology pedagogy content alignment is what converts tools into cognitive engagement (Bian & Mohd Zaid, 2025). Turinumukiza et al. (2025) statistically modelled smart classroom utilisation in rural Rwandan secondary schools and found pedagogical readiness, technological infrastructure, and institutional support to be the strongest enabling predictors of interactivity a configuration directly instructive for Tanzanian planning. Institutional leadership completes the enabling triad; principal support, school ICT policies, and functioning technical support structures distinguish schools where technology is embedded from those where it lies idle (Mogas et al., 2022, Turinumukiza et al., 2026a).

Student Engagement and Motivation

Interactive technologies reshape students' learning experiences in ways that both enable and evidence smart classroom value. In Tanzanian schools, students report that tablets and interactive whiteboards make lessons more interactive and engaging, and ICT supported lessons improve understanding through videos and animations (Daudi & Nzilano, 2019; Nsyengula et al., 2025; Senyagwa, 2020). Comparable evidence from Botswana's SMART Technologies pilot found high engagement with technology use, 78% of students reporting moderate to high motivation and 72% reporting better performance in subjects using SMART boards (Tsayang et al., 2020). Interactive whiteboards similarly increased enjoyment, interest, and participation in Israel middle and senior high schools (Manny-Ikan et al., 2011), and quasi experimental evidence from India links smart classroom instruction to higher engagement and stronger creativity achievement correlations (Malik & Shanwal, 2017).

Engagement is maximised when technology supports peer interaction and cognitively demanding tasks rather than passive presentation. Turinumukiza et al. (2026b) measured interactivity, collaboration, critical thinking, and active engagement in Rwandan smart classrooms, finding strong correlations between engagement and collaboration and between engagement and critical thinking, with engagement highest when lessons emphasised peer interaction. Design research in Canadian smart classrooms shows that large shared displays and real time aggregation of student work transform group problem solving, raising accuracy from 50% to 81% (Tissenbaum & Slotta, 2019), and immersive simulations produced significant conceptual gains in

secondary biology (Lui & Slotta, 2014). On the learner side, internet self-efficacy, internet use, and internet attitude significantly predict higher order outcomes such as computational thinking in smart classroom environments (Xing & Lu, 2022), while technology self-efficacy operates as the prerequisite driver of perceived ease of use, satisfaction, and ultimately academic performance in African smart classrooms (Ngendahayo et al., 2024). These findings converge on a central enabling insight, smart classrooms cultivate engagement and higher order thinking when they are designed around interaction, and when learners possess the self-efficacy to exploit them.

Barriers to Implementation

Financial Constraints

Cost is the most cited barrier in the corpus and the most structurally entrenched. Saini and Goel (2019) articulate the canonical argument, fully equipped smart classrooms are "exorbitant" relative to blackboard and chalk classrooms and are unaffordable at per classroom scale in populous developing countries, necessitating shared hardware and unified framework solutions. The arithmetic in Tanzanian and comparable settings is stark. In Nigeria's public junior secondary schools, rural schools average 81 students per computer compared with 8–13 in private schools (Bello Mubarak & Adekola Kamaldeen, 2026); in Tanzania's Mbeya region, rural schools describe one computer for the entire school, frequently broken or reserved for administration (Nsyengula et al., 2025). In Swaziland, high internet access costs flowing from a seven ISP, urban-centred market compounded already strained equipment budgets (Madzima et al., 2012). Chronic underfunding below UNESCO's 15–20% benchmark, the total cost of ownership (training, maintenance, connectivity, and short two to three-year device lifecycles rarely budgeted for), and donor dependence that leaves facilities unmaintained when projects end completes the financial picture (Fomunyam, 2019, Makinde et al., 2024, Wagner, 2016). Sani et al. (2026) found that schools without dedicated AI budgets or maintenance arrangements default to teacher centred methods, demonstrating that financial constraint is not merely an adoption barrier but an outcome barrier.

Lack of Technical Support and Infrastructure Reliability

Where infrastructure exists, its reliability determines whether it is used. Tanzanian evidence is consistent with the regional picture. In Rwanda's Gicumbi District, 54.3% of teachers reported that technical support was rarely available and 48.6% received no help when devices failed (Turinumukiza et al., 2026a), figures mirrored in Tanzania's Dar es Salaam region, where 80% of teachers cited lack of technical support (Mafang'ha, 2016). Joseph (2021) found 60% of Mtwara teachers lacked technical support, and unreliable electricity and internet connectivity recur in every Tanzanian study from Serengeti to Mbeya (Komba et al., 2025, Warioba, 2020), and IoT deployments register environmental discomfort, with temperatures above 27°C reducing classroom occupancy (Perfectson et al., 2025). Kizilcec et al. (2021) add an ownership layer constraint, even where services are free, gendered gaps in phone ownership and parental work obligations limit children's access. The composite picture is that hardware without maintenance systems, power without backup, and connectivity without technical staffing produces what Turinumukiza et al. (2026a) call projection spaces rooms equipped as smart classrooms but functioning as passive display venues.

Cultural and Social Factors

Human and social barriers operate alongside material ones. Teacher attitudes constitute the most frequently reported soft barrier, reluctance to change, fear of technology, low motivation, and preference for established methods appear across Tanzanian studies (Mafang'ha, 2016, Mfaume, 2019; Senyagwa, 2020), and negative attitudes were cited by 88% of Ilala District teachers as a determinant limiting ICT use (Mafang'ha, 2016). Age and teaching experience moderate acceptance, with generational gaps between younger and older teachers documented in Dar es Salaam (Mafang'ha, 2016; Manyama & Ndibalema, 2017). Digital literacy gaps among teachers reported as the single most cited challenge (54%) in an SSA wide review of mobile learning in secondary schools convert capable hardware into unused stock, memorably described in Mbeya as donated tablets sitting in storage for want of training (Mabalane, 2025, Nsyengula et al., 2025).

Social barriers extend to learners and communities. The digital gender divide manifests in device ownership, digital literacy, and cultural norms restricting girls' technology use, with Nigerian data showing 34% of girls versus 62% of boys owning devices (Ogunwale, 2025), Rwandan evidence adds that male students perceive smart classroom technology as easier to use than females do, an effect the authors argue pedagogy can mitigate (Ngendahayo et al., 2024). The language of instruction interacts with technology. English language dominance of online content disadvantages Tanzanian learners (Madzima et al., 2012, Tikly et al., 2018), and algorithmic systems trained on non-African data embed linguistic and cultural mismatch (Jonathan et al., 2025; Mugoniwa, 2026). Finally, concerns about distraction, diminished handwriting, cyberbullying, and weakened socio-emotional interaction temper enthusiasm for technology saturated classrooms (Chukwuemeka, 2025, Joyce-Gibbons et al., 2018; Goagoses et al., 2024).

Policy and Governance Issues

The final barrier layer is institutional. Tanzanian teachers operate amid policy contradictions a 2007 ICT policy aspiring to technology integration alongside a 1978 Education Act that never contemplated it and report unclear institutional and curriculum guidance on technology use (Mubofu & Adoph, 2026, Warioba, 2020). Kihoza (2016) documented the absence of a national ICT integration framework as a primary obstacle, while Peter (2023) found missing governance structures and absent policies among the constraints on e-pedagogy in Tanzanian secondary schools. Fragmentation characterises the wider region, uncoordinated draft policies, weak inter agency coordination, inconsistent monitoring and evaluation, and policy discontinuity under political instability (Akomolehin & Aluko, 2025; Madzima et al., 2012). Data governance has emerged as a frontier policy gap, with privacy, security, algorithmic bias, and AI-assisted cheating requiring regulatory responses that few SSA systems have yet formulated (Dimitriadou & Lanitis, 2023, Jonathan et al., 2025; OECD, 2021). Langthaler and Bazafkan (2020) conclude, on SSA wide evidence, that governance and regulation rather than technology per se determine whether digitisation reduces or deepens inequity, a judgment directly applicable to Tanzania's smart classroom ambitions.

Educational Outcomes

Academic Performance

The strongest outcome evidence is causal and comes from the region. Evaluating The Gambia's interactive whiteboard and student responder programme with a quasi-experimental design, Blimpo et al. (2020) found mathematics gains of +0.59 standard deviations on the West African Senior School Certificate Examination and a fifteen-percentage point increase in students earning credit in both mathematics and English. At national scale, Nsabimana et al. (2024) evaluated Rwanda's smart classroom programme across 318,643 lower secondary students using staggered rollout, finding gains of 0.002–0.004 standard deviations per month of exposure in physics, biology, and geography with effects near zero in the first ten months, positive for all subjects after twenty-one months, and larger for girls and for government aided schools. This dose-response pattern establishes sustained exposure as a condition of impact. In Gakenke District, the type of digital resource accessed significantly predicted academic performance, with 82.9% of students agreeing digital resources improve grades (Nshunguyimana et al., 2025). Structural models extend the chain; in Rwandan A-level STEM schools, learner satisfaction with the smart classroom directly predicted academic performance, with technology self-efficacy as the prerequisite driver (Ngendahayo et al., 2024); in Chinese secondary schools, internet self-efficacy, use, and attitude explained 28.4% of computational thinking variance (Xing & Lu, 2022).

Globally, Chen and Liu's (2024) meta-analysis of 21 empirical studies provides the quantitative frame, smart classrooms produced large positive effects on cognitive outcomes (SMD = 1.014, with achievement at 0.912 and recognition memory at 1.970) and behavioural outcomes (SMD = 2.155), but near zero affective effects, with stronger results in primary than secondary schools, in STEM than social science subjects, in larger classes, and under problem based learning. Design based outcome studies confirm measured gains, immersive simulations raised secondary biology concept inventory scores. (Lui & Slotta, 2014), and smart classroom instruction showed significant post-test advantage in Indian Grade 8 classrooms (Malik & Shanwal, 2017). AI-specific evidence is accumulating adaptive platforms produced 23% test-score improvements and a 15%

dropout reduction in African deployments (Ogunwale, 2025), and gamified instruction significantly improved motivation and concept mastery in Nigerian public schools (Bello Mubarak & Adekola Kamaldeen, 2026).

Tanzanian outcome evidence, by contrast, is overwhelmingly perception based a critical gap. Teachers in Morogoro and Mvomero associated ICT supported lessons with better student performance and understanding (Senyagwa, 2020), Serengeti teachers reported ICT facilitates academic performance, saves time, and enhances interaction (Warioba, 2020); Mbeya teachers found Google Classroom users outperformed non-users and reported improved long-term memory and attention (Komba et al., 2025) and 93.2% of Dar es Salaam teachers agreed ICT facilitates academic performance (Warioba, 2020). Students using ICT obtained better grades and expressed positive attitudes linked to performance intentions (Daudi & Nzilano, 2019), and Mtebe et al.'s (2016) multimedia programme upgraded teachers' content knowledge with pass rate improvements intended though not experimentally measured. One Tanzanian study does connect technology to a hard outcome at scale. Mnyawami et al. (2022) used automated machine learning on 206,885 student records to predict dropout with up to 99.8% accuracy, demonstrating a measurable, intervention ready outcome of smart education data systems. The national documentary evidence that students with access to digital learning tools performed better in language proficiency tests, while observational, points the same direction (Nsyengula et al., 2025).

Skill Development

Beyond test scores, smart classrooms are credited with cultivating twenty first-century skills. Reviews grounded in the ICAP framework show that interactive and constructive engagement modes in smart classrooms are linked to deep learning, with cognitive engagement operating as the bridge between technology affordances and performance (Bian & Mohd Zaid, 2025). In Tanzanian secondary schools, e-pedagogy models built around games, gamification, group brainstorming, and role play aim precisely at creativity, collaboration, problem solving, and communication (Peter, 2023), and blended learning frameworks target the 4Cs critical thinking, communication, collaboration, and creativity (Kihoza et al., 2016, Kihoza, 2016). Measured process evidence from Rwanda shows technology improving surface engagement more readily than deep outcomes, with critical thinking and collaboration developing unevenly (Turinumukiza et al., 2026).

Teacher and Student Perspectives

Perceptual evidence, while methodologically weaker, is voluminous and directionally consistent. Teachers across Tanzania perceive smart classroom technologies as enhancing engagement, interactivity, understanding, learner-centred instruction, and communication, with high utilisation of projectors, PowerPoint, YouTube videos, and mobile applications alongside low utilisation of advanced platforms (Odezue et al., 2026, Tanzanian students value the interactivity tablets and whiteboards bring to language lessons (Nsyengula et al., 2025), and Ilala students skilled in ICT obtained good grades and expressed positive attitudes (Daudi & Nzilano, 2019). Teachers appreciate saved preparation time, automated feedback, and workload reduction, with generative AI partnerships reporting workload reduction scores rising from 2.2 to 4.0 on a five-point scale (Kamaghe, 2026). Two cautions accompany these positive perspectives. First, perception is not measurement engagement, the most commonly claimed benefit, shows near-zero effect on affective outcomes in meta-analytic evidence (Chen & Liu, 2024), and the OECD's (2021) PISA analysis finds technology use intensity alone negatively associated with performance a reminder that uncritical adoption can displace effective instruction. Second, engagement gains risk decaying without pedagogical challenge, the halo effect documented in IWB evaluations (Manny-Ikan et al., 2011). Student perspectives should therefore be read as necessary but insufficient evidence of educational value.

DISCUSSION

6.1 Synthesis of Findings

Synthesised across the corpus, the evidence describes a single interacting system rather than three separate lists. Enabling factors operate in a chain infrastructure and institutional support create the conditions, teacher pedagogical readiness converts equipment into practice, and learner self-efficacy converts practice into engagement and the chain breaks at its weakest link. Turinumukiza et al.'s (2025) regression model captures

this precisely; infrastructure, readiness, and support each significantly predict utilisation, but rigid teacher centred pedagogy actively suppresses active engagement. Li et al. (2015) documented the same phenomenon as large actual preferred gaps on every core smart classroom dimension, and Turinumukiza et al. (2026a) observed it ethnographically in Tanzanian conditions, smart classrooms functioning as projection spaces where equipment is present but personalisation, investigation, and interaction are absent. The central synthesis of this review is therefore that provision does not equal use, and use does not equal learning each transition depends on the pedagogical and institutional layer beneath it.

The outcome evidence sharpens this synthesis. Effects are real but conditional, they are largest in STEM subjects, under problem based learning, with sustained exposure of more than ten to twenty-one months (Chen & Liu, 2024, Nsabimana et al., 2024), and they accrue to girls and low prior achievers when access is equitable (Bello Mubarak & Adekola Kamaldeen, 2026; Nsabimana et al., 2024; OECD, 2021). The dose-response finding carries direct implications for Tanzania, where pilot projects frequently end before exposure thresholds are reached. The near-zero effects in the meta-analysis and the PISA intensity caution together argue that Tanzanian policy should optimise how technology is used interactive, constructive, curriculum integrated rather than how much of it is present.

Implications for Policy and Practice

For government and educational authorities, the review supports five priorities; First, treat reliable electricity, connectivity, and maintenance systems as the foundation of any smart classroom investment, favouring solar-powered, offline capable, and shared hardware configurations that match fiscal reality (Blimpo et al., 2020; Saini & Goel, 2019). Second, fund teacher professional development as an ongoing system rather than episodic workshops, structured around TPACK and tied to curriculum integration, with cascade and community of practice formats for scale (Bian & Mohd Zaid, 2025; Gardner et al., 2018; Mtebe et al., 2016). Third, resolve policy fragmentation by articulating clear institutional and curriculum guidance for technology use and establishing data governance rules for AI applications (Kihoza, 2016; OECD, 2021). Fourth, design for equity from the outset gender responsive access strategies, local language content, and explicit rural provisions since the gender and rural-urban gaps documented across the corpus widen without deliberate counter measures (Langthaler & Bazafkan, 2020; Ogunwale, 2025). Fifth, embed continuous evaluation into every initiative; the corpus repeatedly notes that flagship programmes proceed without rigorous outcome tracking (Gardner et al., 2018; Wagner, 2016). For schools, leadership commitment, functional technical support arrangements, and timetabled collaborative planning emerge as the practicable levers. For NGOs and development partners, the evidence favours long horizon, outcome linked commitments over equipment donation, aligning with calls for comparative, longitudinal designs (Chukwuemeka, 2025; Turinumukiza et al., 2026).

Limitations and Gaps in the Literature

Three gaps qualify the conclusions. First, the Tanzanian evidence base is perception heavy; most local studies measure attitudes, readiness and self-reported benefits rather than learning gains, and the strongest causal evidence is imported from Rwanda, The Gambia, and Nigeria. Transfer is justified by contextual similarity but remains inferential. Second, several retained sources address higher education or system level policy and were transferred to the secondary level with caution (van der Merwe et al., 2023), and some conceptual papers contribute framing rather than evidence (Grosu, 2024; Serin, 2022). Third, the review itself is narrative rather than meta-analytic; heterogeneous designs, outcomes, and instruments precluded pooled estimation, and publication bias toward positive findings cannot be excluded. These limitations define the research agenda rather than negate the synthesis.

Directions for Future Research

Future studies should prioritise; (a) quasi-experimental and randomised evaluations of Tanzanian smart classroom programmes with pre-registered outcome measures, replicating the Rwandan staggered rollout design (Nsabimana et al., 2024); (b) longitudinal research linking measured utilisation to student learning over the critical ten to twenty one month exposure window (Turinumukiza et al., 2026); (c) implementation studies connecting open educational resource and AI tool adoption to measurable achievement, an explicit

recommendation of recent Tanzanian work (Mubofu & Adoph, 2026); (d) gender disaggregated analyses of access, self-efficacy, and outcomes in Tanzanian smart classrooms (Ngendahayo et al., 2024; Ogunwale, 2025); and (e) studies of data governance, privacy, and algorithmic bias as AI scales into Tanzanian classrooms (Dimitriadou & Lanitis, 2023; Mugoniwa, 2026). Building national research capacity to conduct such studies, rather than depending on donor driven evaluations, is itself a policy priority.

CONCLUSION

This narrative review has consolidated 44 studies into a coherent evidence base on smart classroom technologies in Tanzanian secondary schools. The enabling factors are well understood infrastructure, institutional support, pedagogically grounded teacher development, and learner self-efficacy and the barriers are stubbornly consistent; cost, unreliable power and connectivity, absent technical support, digital literacy gaps, socio-cultural resistance, and policy implementation deficits. The outcomes evidence, while strongest outside Tanzania, demonstrates that technology integrated classrooms can produce substantial learning gains when exposure is sustained, pedagogy is interactive, and equity is engineered by design. For Tanzania, the strategic implication is clear; the next phase of investment should shift from equipping classrooms to enabling the full chain power, maintenance, trained teachers, interactive pedagogy, and rigorous evaluation so that smart classrooms cease to be projection spaces and become genuinely intelligent learning environments. If that shift occurs, the reviewed evidence indicates that Tanzanian secondary students stand to gain measurably in achievement, skills, and engagement.

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