A Framework for Scaling EdTech Impact: Six Stages for Sustainable Education Technology Reform in Sub-Saharan Africa

An Education Systems Strengthening Framework for Practitioners in Low Resource Settings.

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Acronyms

AfDB	African Development Bank
AI	Artificial Intelligence
AU	African Union
CGA	CGA Technologies
DRC	Democratic Republic of Congo
DLP	Digital Learning Program (Kenya)
EdTech	Education technology
EMIS	Education Management Information System
ETRI	EdTech Readiness Index
GDP	Gross Domestic Product
GISI	Girls in School Initiative
GPE	Global Partnership for Education
GSMA	Global System for Mobile Communications Association
HDI	Human Development Index
HereMIS	Student and teacher attendance management information system developed by CGA Technologies
HR	Human Resources
HQ	Headquarters
ICT	Information and Communications Technology
IT	Information Technology
KES	Kenyan Shilling
LLM	Large Language Model
LMIC	Low- and Middle-Income Country
mSRC	Mobile School Report Card (Ghana)
MoE	Ministry of Education
MBSSE	Ministry of Basic and Senior Secondary Education (Sierra Leone)
NBER	National Bureau of Economic Research
NEMIS	National Education Management Information System (Kenya)
OECD	Organization for Economic Co-operation and Development
OLPC	One Laptop per Child
PER	Public Expenditure Review
PISA	Program for International Student Assessment
RCT	Randomized Controlled Trial
SD	Standard Deviation
SMS	Short Message Service
TAM	Technology Acceptance Model
TSC	Teaching Service Commission (Sierra Leone/others)
TMIS	Teacher Management Information System
TRM	Teacher Records Management
USD	U.S. Dollar
Wi De Ya	“We Are Here” (Krio) Sierra Leone’s education attendance monitoring system

Contents

1 Executive Summary

Education technology (EdTech) investments in sub-Saharan Africa have consistently underperformed relative to their stated objectives. The constraining factor is not the technology itself but ineffective sequencing of the investments: devices and classroom tools have been deployed before the administrative, infrastructural, and human systems required to sustain them are in place. This paper argues that slower sequencing of EdTech reform is more likely to achieve long run aggregate learning outcomes than pace. This paper proposes six sequential stages through which governments, donors, and implementing partners should structure investment to achieve sustainable digital transformation in education.

The six stages proposed are: (1) establishing reliable power and connectivity; (2) digitizing and cleansing teacher payroll and HR systems; (3) establishing a national school master list and common data framework; (4) building decentralized administrative and management capacity at district level; (5) equipping school leaders with data systems to generate better data and use it to manage attendance, assessment, and teacher performance; and (6) integrating classroom-facing technology for learners. Collectively, the stages in the sequence are cumulative: each stage is hypothesized to create the conditions to make the next stage efficient and sustainable. Where prerequisite stages are skipped, this paper argues programs may stall, fail to scale, or collapse once external funding ends.

This framework is practitioner-derived, developed inductively from implementation experience working with education ministries in West, East, and Central Africa, and corroborated against the available empirical literature. The sequential claim itself has not been experimentally verified; no comparative evidence exists, to the authors' knowledge, that directly tests the efficiency consequences of alternative orderings. The framework is offered as a structured hypothesis to guide investment prioritization, and as a contribution to a field where conceptual precision on sequencing is currently limited.

The primary implication for donors and governments is that external funding timelines, which typically favor visible classroom-level outputs over robust "nuts and bolts" digital public infrastructure, are misaligned with the investment horizon required for sustainable EdTech reform. Investments that follow this sequence—particularly ones that prioritize data infrastructure and systems with fiduciary implications including payroll integrity—are the ones most likely to sustain classroom technology at scale and generate commensurate long-term learning gains.

2 Introduction

Education's long-run contribution to economic growth has been demonstrated repeatedly in literature, including by Becker et al. (1990), Romer (1994), World Bank (2018), and Wong et al. (2026). Education sits at a tension point between two of its assumed functions: (1) assuring continuity and (2) fostering creativity and change. The role of emerging technologies forces this tension to the forefront. General technology uptake by educators has been studied in depth (Scherer et al., 2019) but the sector has not codified optimal investment priorities to maximize the output of investments in EdTech. This paper therefore focuses not on the technological advancements themselves, nor how to teach them, but on how the sector builds conditions for such investments to sustainably and impactfully take root. EdTech here is defined as the use of electronic technologies to improve educational outcomes, including learning, retention, teaching effectiveness, cost efficiency, and access, building on Veletsianos and Moe (2017[1]).

[1] Veletsianos and Moe go on to make the case that higher education in the USA is using EdTech to commercialize, rather than improve outcomes. Fragile and low resources settings have a long way to go before education is delivered so consistently.

Learning is fundamentally a product of relationships. This begins with the core relationship between learners and their educators, but learning extends beyond the classroom, rippling into the broader school system, families, and communities through social networks and shared practices. Every process around this core relationship should reinforce a productive learner–teacher dynamic. For this reason, this practitioner paper emphasizes the centrality of teacher support and the management structures that enable it. Well-designed processes to manage and support teachers and teaching are an essential feature of any education system, and, supported by technology, these processes can foster more effective learning environments than ever before.

As the global growth of learning inequality looms and threatens unprecedented levels of missed or wasted opportunity for young people, this paper will set out why and how to ensure education systems are well structured with robust foundations. Failure to do so should be challenged as "poorly governed educational systems do not allow firms to extract the full potential of human capital for innovation" (Barasa et al., 2017, p. 283).

2.1 The Case for Sequence in EdTech Reform

Politics

The drive to digitalize education reflects a shared commitment among governments, ministries, and partners to expand access and improve learning outcomes in sub-Saharan Africa. However, the urgency for reform has often prioritized speed over ensuring strong foundations are in place.

As such, there is a need to develop a "conceptual precision" to prioritize and build a case for optimized investment (Honadle, 1999). Public sector reform, investment priorities, public financial management, and strengthening accountability are all areas that require governments to make choices that will have political effect, and so coherent steps matter (Ezegwu et al., 2023, p. 75; Marcinowski et al., 2024; Cardona, 2007, as cited by Marcinowski).

In times of uncertainty, core service delivery must be prioritized while inflexibility must be avoided. However, one change that appears unlikely to alter course soon is that external, sector-altering funding is contracting. Therefore, governments less likely to benefit from the ebb and flow of external funding or technical assistance should prioritize consistent long-term investment, including building and maintaining an effective, well-managed workforce, before funding high-risk, low-sustainability initiatives that fail to reinforce these fundamentals.

In aggregating cumulative education outcomes, a chatbot today, without electricity to support the device or the teachers, is a temporary investment. For EdTech to scale, the order of reform may matter more than the pace. Lasting digital transformation is not built on isolated tools, but on a coherent, sequenced architecture (Hackman and Reindl, 2022; Marcinowski et al., 2024). When is a framework required? Education system actors are part of the resource constrained political economy and so compete for public budget.

Equity

A tension in the foundations of this framework is whether scarce resources should raise the floor for all learners or concentrate on developing a cadre of high performers who drive innovation and economic leadership. For low resource settings, the weight of evidence strongly favors the former.

Hanushek and Woessmann demonstrated in 2012 that cognitive skills of the population at large, rather than years of schooling alone, are causally related to long-run economic growth. Then, Gust, Hanushek and Woessmann (2024) estimate that 94% of youth in sub-Saharan Africa fail to reach basic skill levels, and that closing this gap would yield economic returns in orders of magnitude above current GDP. The World Bank's 2025 Africa Pulse report estimates that universal foundational learning could double sub-Saharan Africa's

GDP per capita by 2050 (World Bank, 2025). The OECD's cross-national Program for International Student Assessment (PISA) analysis finds that the highest-performing systems internationally are those that combine equity with quality, not those that sacrifice one for the other (OECD, 2012).

The counterargument draws on endogenous growth theory. Vandenbussche, Aghion and Meghir (2006) and Acemoglu, Aghion and Zilibotti (2006) demonstrate that the growth contribution of tertiary education increases as economies approach the technological frontier. However, some sub-Saharan African economies are far from that frontier, which means that the requirement for broad basic skills currently dominates. Elite investment becomes growth-critical only after foundational provision is substantially in place. The World Bank's Africa Centers of Excellence program illustrates that selective higher-education investment can complement rather than substitute for universal provision, but only where broader systems function (World Bank, 2025).

The implication for this framework is direct: sequencing foundational investment before concentrated excellence is not merely an equity argument but an efficiency one. Countries that attempt to produce elite graduates from systems where the majority cannot read will achieve neither equity nor excellence.

EdTech Readiness

The World Bank's EdTech Readiness Index (ETRI) assesses nation-level feasibility across six pillars—school management, teachers, students, devices, connectivity, and digital education resources—based on the perspectives of school leaders. While ETRI provides a valuable snapshot of where systems stand, this white paper seeks to expand the scope offered by that framework by proposing how progress across these pillars should be sequenced for sustainable digital transformation.

The debate around whether to invest in initiatives that digitize classroom-level functions ought to be grounded in the establishment of supportive foundations that are herein discussed. There is appetite to develop and rely on accountable, logged, and systematized processes underpinned by established digital infrastructure.

The Six-Stage Framework

Corus' experience of implementing systems—from granular school-level attendance tools to integrated national Education Management Information System (EMIS) and Teacher HR Management platforms—provides direct evidence for this staged approach. Corus has learned, along with its government partners, that building the foundational data layers first enables the subsequent deployment of technologies that are scalable, interoperable, and aligned with ministry priorities.

Stage 1 focuses on infrastructural spend, which is often beyond the means and the mandate of the education sector. Stage 2 addresses the importance of quality teachers and typically requires close collaboration with the Ministry of Finance or a public service ministry. Stage 3 targets the management of education resources: ensuring an accurate count of schools, for example. Stage 4 requires building capacity, often decentralized, to enable more effective local decisions on resource deployment and accountability up and down the chain. Stage 5 focuses on the effective delivery of structured pedagogy, managing schools, managing teachers, understanding learners, conducting individual learning assessments, and delivering high impact learning outcome initiatives. And finally, Stage 6 centers on providing additional digital resources for classroom-level learning, including the provision of devices for learners.

3 Methodology

3.1 Epistemological Position and Analytical Approach

The framework was developed abductively, drawing the hypothesis from practitioner-observed implementation constraints and subsequently interrogated against available empirical literature, beginning from the classroom and working outward to identify the structural conditions that each level of the system depends upon, consistent with theory-building synthesis (Torraco, 2005; Rocco and Plakhotnik, 2009).

The analytical starting point was a single, grounded premise: that classroom-level EdTech requires functioning teachers in attendance, and working, trained teachers require effective management and reliable payment. From this premise, the analysis worked inductively outward—identifying the structural constraint on each preceding condition. Teacher effectiveness depends on school-level management; school management depends on district-level administrative capacity; district capacity depends on accurate system data, including school registries and workforce records; and all electronic systems depend on reliable power. This constraint-mapping process generated the six-stage sequence presented below.

The framework is not an experimentally verified causal model. It is offered as a contribution to conceptual development in EdTech governance, subject to empirical validation. No randomized or quasi-experimental evidence exists, to the authors' knowledge, that validates the ordering of these stages as an efficiency-maximizing sequence at system level; that absence is itself a finding. Further empirical work—ideally comparative case analysis across systems at different stages of implementation—is identified as a recommendation.

3.2 Search and Limitations

The search and analysis were conducted by a single researcher. The absence of dual review introduces unquantifiable selection bias. This paper should be understood as a narrative synthesis rather than a systematic review, with the associated reduction in replicability and the attendant increase in the role of researcher judgement.

Inclusion and Exclusion Criteria

Searches were conducted in English only. No francophone, lusophone, or other non-English literature was reviewed. Given that a substantial proportion of the countries most directly relevant to this framework—including those in West and Central Africa—operate primarily in French, this constitutes a material evidence gap that may systematically underrepresent implementation contexts in those regions.

Date parameters were differentiated by stage to reflect the epistemological age of the evidence base relevant to each analytical question.

- Stage 1, power and connectivity: no lower bound
- Stages 2-5, administrative systems, EMIS, district capacity, school management: 1998 (post-internet)
- Stage 6, classroom technology: 2014-present (the first large-scale, one device per learner program identified).

Searches were conducted for evidence both supporting and challenging each stage's proposed position in the sequence. Counter-evidence for Stages 1 and 2 is sparse, which is consistent with the near-tautological nature of the underlying claims: electronic systems require power, and payroll integrity is a precondition for managing any workforce. Counter-evidence is more substantial for Stage 6 and is incorporated.

Preferred for inclusion:

- Peer-reviewed, published academic journal articles, treated as the primary evidentiary standard throughout, including systematic reviews, meta-analyses, randomized controlled trials (RCTs), and quasi-experimental designs with explicit sample size reporting
- Studies situated in West, East, or Central Africa, or sub-Saharan Africa broadly; country-specific studies from the region were included alongside continent-level searches
- Where multiple studies address the same question, larger sample sizes and broader geographic scope were weighted more heavily

Grey literature from multilateral institutions—the World Bank, UNESCO, UNICEF, IEA, GSMA, AfDB, and ILO—was admitted where peer-reviewed evidence was sparse or absent. Grey literature is cited with explicit identification of its source type and is not treated as equivalent to peer-reviewed evidence.

Working papers and pre-publication manuscripts from established research institutions—including the National Bureau of Economic Research (NBER), where Beg et al. (2020) and Angrist et al. (2022, 2023) are cited—were admitted where they represent the primary available evidence on a question. Peer-reviewed publication was preferred where available on the same empirical claim but working paper status was not treated as grounds for exclusion.

Studies relying exclusively on self-reported outcomes without corroborating quantitative or experimental evidence were weighted lower than independently verified evidence but were not excluded, particularly where they constituted the primary available evidence at a given stage. Sources without an identifiable methodology or empirical data basis were excluded.

Treatment of Organizational Evidence

Evidence generated by Corus International and CGA Technologies—including program data from the Wi De Ya school attendance system, the Teacher Management Information System in Sierra Leone, and the Girls in School Initiative—is included as non-experimental case study material. It is treated as illustrative evidence of implementation context and practitioner perspective. It cannot be regarded as independent validation of the framework; it constitutes, rather, the starting point for the analytical questions that the literature review then interrogates.

Where organizational data are cited, they are explicitly identified as such. Readers are advised to apply appropriate caution in weighting this evidence relative to independently generated and peer-reviewed sources.

4 The Sequence Framework

4.1 Stage 1: Establish reliable infrastructure for power and connectivity

Hassan et al. (2022) demonstrate the importance of the learning environment on the learning that takes place within. Classrooms need light, humans need toilets, doors need locks, windows need shutters. If schools are to protect the hardware, it follows that they need to protect the books, too. The general learning environment is beyond the scope of this framework but the same principle applies to the conditions for EdTech; in this case what is required is power and network.

Electricity

Electricity—or lack thereof—is the single biggest constraint to EdTech reform. Without dependable power, every subsequent stage of digital reform is constrained, as devices may not run, networks may not connect, and data systems may not operate. The sector can and does operate around this constraint: the Teaching Service Commission Sierra Leone uses commercial charging stations within communities and, in some cases, solar power banks, while le Service national de l'identification des élèves (SERNIE) Directorate in the Democratic Republic of Congo (DRC) works at the last-mile using paper forms, relying on enumerators to digitize the data at the regional level where it is more cost effective to secure power. While the workarounds for EdTech at the school level vary, the common thread is that power remains a fundamental constraint on how far EdTech may be applied and at what scale.

Around 600 million (40%) people in Africa still live without electricity, and this group represents more than 80% of the global population who lack electricity. Delivering universal access by 2030 requires an annual investment of US$25 billion, far greater than any current funding flow (IEA, 2024 and 2025). To supply power to all schools would require an investment in the region of 2 billion EUR (approximately US$2.3 billion) (Moner-Girona et al., 2025).

A joint World Bank-AfDB initiative, Mission 300 seeks to connect 300 million Africans to electricity by 2030, roughly half of those currently unconnected, through financial incentives for private and public investment. It prioritizes connection to schools in addition to businesses and homes, recognizing that electricity is not only a household service but a foundational requirement for education and health provision, as well as economic growth. Connected schools can serve as community hubs, providing reliable access points for power and connectivity to students, educators, and surrounding households in remote areas (AfDB, 2025).

However, there are currently no initiatives of equivalent scale that explicitly target the remaining half of the access gap (World Bank, 2026; IEA, 2025). That means that even if Mission 300 achieves its ambitious goal, at least 300 million people (around one-fifth of the continent's population) and many thousands of schools, health centers, businesses and other infrastructure would still lack access to reliable power.

So, while significant progress in tackling the single biggest constraint to EdTech reform is being made, strategies must recognize and plan for this infrastructural shortfall to ensure the final 20%—who live in fragile, remote or conflict affected areas—are reached. In the intervening period, it is possible to fill that gap programmatically with solar, generators and power banks to avoid the risk of backsliding. However, this comes at greater long-run cost per user and reflects a missed opportunity for efficient value-for-money investment as well as a lack of sustainability.

Connectivity

Second to electricity in this framework is the need for connectivity via the internet or mobile network coverage. While not strictly a prerequisite for every EdTech activity, connectivity is essential for systemic, sustainable EdTech reform.

Across Africa, 89% of people live within mobile-network coverage—leaving some 168 million people with no coverage at all. Those without coverage often live in the least populated and hardest-to-reach regions. However, coverage alone does not guarantee access. Of those within range, only around 30% use mobile internet, leaving a usage gap of 59%—the largest in the world (GSMA, 2024/2025). Devices and data remain prohibitively expensive to many, limiting the opportunity of bring-your-own-device or community-sharing models, further limiting schools' opportunities to benefit from EdTech even where signal is available.

Where devices are provided, some systems can—and do—operate around coverage gaps. Corus organization CGA Technologies developed a student and teacher attendance management information system, called HereMIS, which functions offline and syncs once within range. But this approach adds complexity. It requires additional app development, device storage, occasional travel to networked areas (which may be costly or far), or 'peer-to-peer' approaches where a device connects with another that has done that travel. The complexity of this can and does impact adoption of systems in areas with poor network. Further, such functionality is the exception and requires being developed to specifically operate in low-connectivity areas. Modern systems are rarely designed for such offline robustness or last-mile use-cases. Many types of EdTech activity have requirements that mean that offline functionality is simply not feasible for effective usage.

Cost and quality of connectivity

Where connectivity does exist, cost and quality are often prohibitive. The scalability issues identified by Skosana et al. (2024) mean that while coverage is improving, the costs remain out of reach for most. Governments can improve affordability through fiscal and regulatory reform: reducing sector-specific taxes and parafiscal fees on telecom operators and users can lower distortions and support wider access to digital services (Rodrigues-Castelan and Pierola, 2022; Niesten and Begazo, 2023).

In schools and education offices, these costs are typically recuring and predictable yet often remain unbudgeted. Schools and district offices frequently cover these costs unsustainably from operational budgets. One cost-effective solution is site whitelisting: in partnership with network operators, ministries can enable free access to work-critical systems (such as EMIS platforms or teacher portals) with costs borne centrally rather than by individual schools

Quality of connection also matters. Of those with network coverage in Central, East, and West Africa, fewer than 30% of people have access to 4G, while large portions of the population remain on 2G networks—limiting digital education to basic, Short Message Service (SMS)-based interventions. In Central Africa, about 30% of users are still on 2G, and in the DRC, 46% of the population lack mobile broadband entirely, while 25% have no mobile coverage at all (GSMA, 2024).

Two parallel priorities must therefore advance in tandem:

1. Coverage must be extended to populations with no connectivity at all. Offline tools can start the journey—enabling stages 2, 3 and 4 in part—but lasting digital transformation, particularly in governance, data systems, and artificial intelligence (AI)-driven learning, depends on consistent, affordable connectivity.
2. The quality of connection must be upgraded from legacy 2G and 3G to 4G and beyond to enable meaningful participation in digital systems. Schools with reliable 3G+ internet can access teaching and learning materials, manage school administration, and communicate effectively.

Adoption of smartphones is estimated to reach 87% in sub-Saharan Africa by 2030; however, GSMA also estimates it could take decades to close the usage gap without policy and affordability action. Cheaper smartphones will fill some of this gap. Policy should bank on rising device penetration and budget for inclusion measures, such as public access points or preparing systems to Bring Your Own Device (GSMA, 2024, 2025).

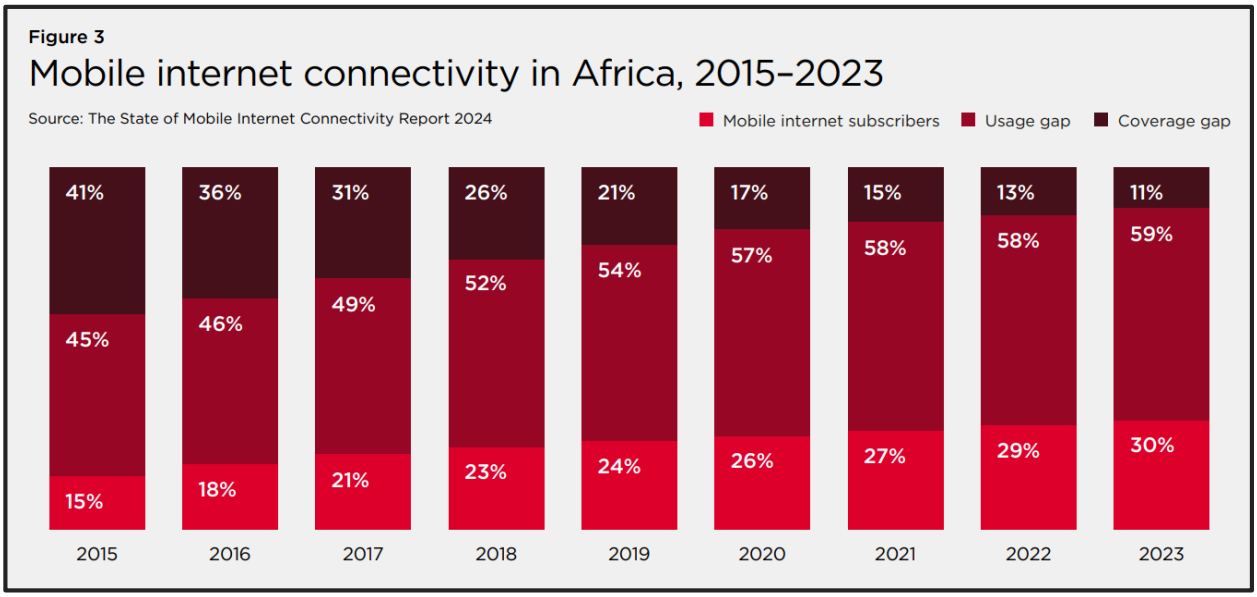


FIGURE 1: MOBILE INTERNET CONNECTIVITY IN AFRICA, 2015-2023. GSMA 2024

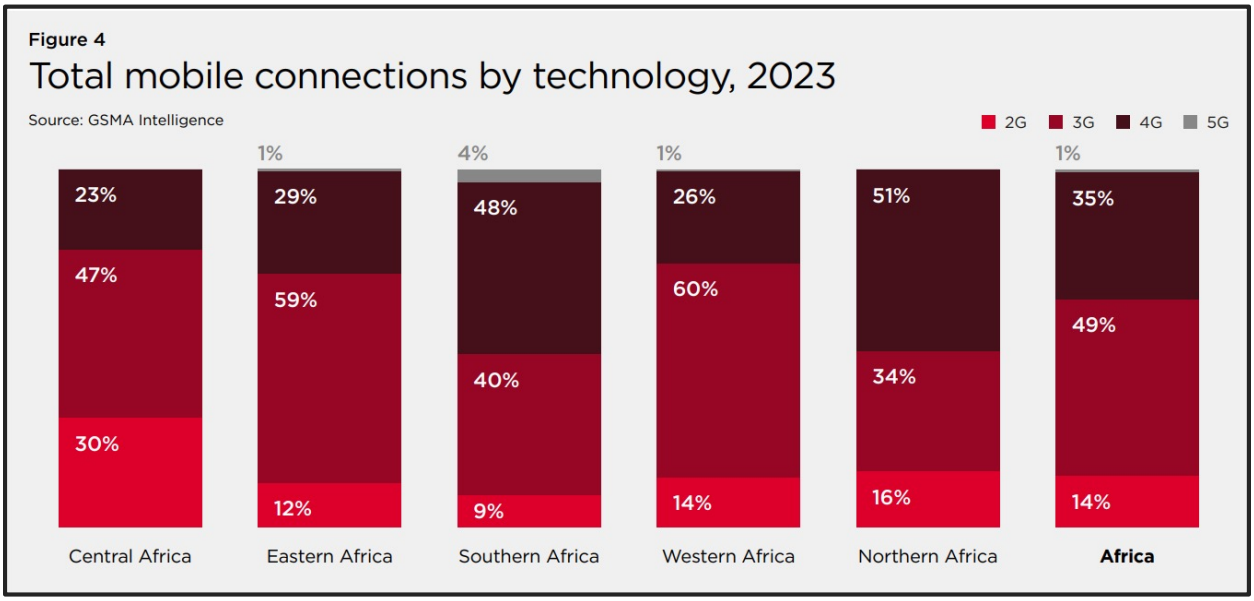


FIGURE 2: TOTAL MOBILE CONNECTIONS IN AFRICA BY TECHNOLOGY, 2023. GSMA 2024

Aker and Mbiti (2010) document how mobile telephony expanded across sub-Saharan Africa at pace and scale despite acute fixed-infrastructure deficits—no landlines, minimal roads, intermittent electricity—producing measurable welfare gains in agricultural markets, financial services, and information access. The mechanism was technological substitution: mobile networks bypassed legacy infrastructure rather than waiting for it. This precedent is directly relevant to Stages 3 and 4. School master lists, district data systems, and administrative workflows have been developed under constrained connectivity across multiple sub-Saharan African contexts.

Mobile-first and offline-first tools may compress timelines for Stages 3 and 4 in ways that do not apply upstream but still apply downstream in the school and in the classroom. At Stages 5 and 6, relying on offline-first technology and generators severely limits the learning possibilities. Therefore, power and connectivity infrastructure is a base level requirement for EdTech systems to work. Where there is power and connectivity, digital reform will have the greatest impact.

Stage 1 Example:

Impact of electrifying school: Kanangawa and Nakata find a strong correlation internationally between energy consumption per capita and the Human Development Index (HDI)'s education index (2008). Absent electricity not only prevents EdTech at scalable prices, but also limits lighting, cooking, fans, and retention of qualified teachers (Sovacool, 2016). Once electrified, 83% of parents said the education experience improved and 34% of school administrators reported their school was used for community activities as a result (Pierce, project report, 2022).

4.2 Stage 2: Implement robust fiduciary and administrative data systems

Teachers make up the largest segment of the public service workforce globally, and their compensation accounts for the greatest proportion of education expenditure (ILO, 2024).

In OECD countries, teacher salaries represent, on average, around two-thirds of total public spending on primary and secondary education. In Low- and Middle-Income Countries (LMICs), particularly those in sub-Saharan Africa, that share is often much higher, exceeding **100% of recurrent education spending** and requiring additional funds (OECD, 2025; Education Commission, 2019, p. 129; Zymelman and DeStefano, 1988).

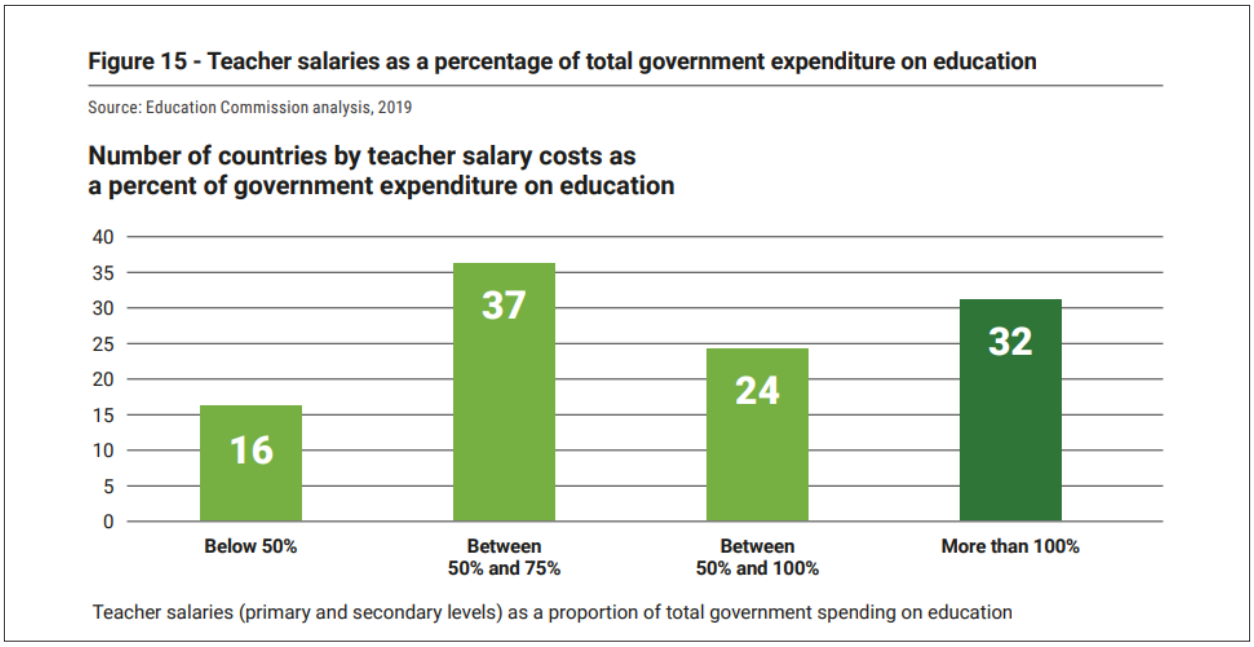


FIGURE 3: TEACHER SALARIES AS A PERCENTAGE OF TOTAL GOVERNMENT EXPENDITURE ON EDUCATION. EDUCATION PAYROLL IS A SECTOR-DEFINING LEVER (EDUCATION COMMISSION, 2019, P.129)

With stakes this high, managing this expenditure effectively is both vital and a powerful lever for improving fiscal discipline and education outcomes. Governments must know who is on the payroll, where they serve, and that they are real. Effective management of teacher payroll expenditure not only ensures effective service delivery, it also increases fiscal space for other spending areas (Ayehu et al., 2026; Bwaki & Tefurukwa, 2022; Schreiber & Kenyah, 2018; Aloriwor et al., 2021).[2]

As a result, financial management and payroll systems are typically the most established and centralized elements of public administration. Yet, despite this, many ministries still operate with incomplete or inconsistent payroll and HR records, unable to validate who is employed, where they work, or whether they are qualified. This opacity fuels inefficiency, undermines workforce planning, and erodes accountability, reducing retention incentives. In Sierra Leone, 43% of teachers in government-supported primary schools were found not to be on the official payroll—meaning they are effectively invisible to the system and pose a significant safeguarding risk (CGA, 2023). Teachers are a primary determinant of education outcomes (Conn, 2017) but

[2] Aloriwor et al. apply fraud models to make the point that this battle to compensate working staff (where there is not the resource to fulfil obligations) will not end without continuous iteration. Bwaki and Tefurukwa state digitization is not the panacea to end this but that it can lift the rug and shine a light where it must be shone.

their management has a more reliable impact on education outcomes than in-service training (Hassan, 2022). And that has external consequences as perceived school quality, including teacher management, influences household schooling decisions (Glewwe, 2002; Chaudhury et al., 2006).

Digitized, auditable payroll systems with **unique identifiers, routine data validation**, and **integration with HR and school management systems** are a foundation for digital reform (Kenya MoE, 2014; World Bank, 2017b, p. 10; van Wyk and Crouch, 2020). They enable ministries to track teachers across locations, reduce fraud, and redirect scarce resources to learning materials, infrastructure, and training.

Digitized HR systems are in the best interests of all stakeholders—from central administration through to teachers, particularly where payroll distribution has shifted from local to central, bypassing middle level management. Moving beyond localized salary distribution reduces inefficiencies, theft, and payment delays but has caused school leaders to report feeling disempowered and it can weaken local influence. Local verification remains critical: school leaders and district officers are best placed to confirm who is teaching and to identify absenteeism. Digitized payroll systems can restore this accountability by combining central efficiency with local input—allowing school leaders and education officers to verify employment status before each pay run (see Stage 5). This approach balances streamlined, transparent payment chains with the practical value of local knowledge, maintaining both control and accuracy in teacher management.

Where administrative data are incomplete, governments often rely on one-off verification exercises, but these provide only a snapshot—verifying who was present on a single day (or even a single hour) rather than maintaining a living record of workforce deployment. These one-off surveys are rendered out of date immediately. Sustained digital systems create ongoing visibility and trust, replacing episodic audits with continuous assurance.

Fiduciary and administrative integrity are not just matters of efficiency; they are, on the available evidence, a necessary precondition for digital transformation. Clean, interoperable payroll and HR data form the basis for reliable EMIS, for data-driven teacher management, and ultimately for informed investment decisions at every level of the system. Before dashboards, analytics, or AI can support decision-making, governments must first know—with confidence—*who is on the payroll, where they serve, and that they are real.*

Stage 2 Example:

Sierra Leone and the Teacher Management Information System.

In Sierra Leone, the Teaching Service Commission's Teacher Management Information System (TMIS) digitizes teacher registration/licensing, recruitment, and core HR processes, replacing paper-based workflows with a single platform designed to integrate with key datasets including payroll and EMIS.[3] It builds on the Teacher Records Management (TRM) work that links more than 30,000 digitized teacher records to payroll, giving the Teaching Service Commission (TSC) an auditable baseline to verify who is being paid and enabling district managers to access records, including qualitative data on their background and qualifications, for evidence-based decisions.[4]

By December 2025, TMIS had registered over 23,400 teachers, recorded over 9,700 licensing exam passes, and supported recruitment of 3,700 licensed teachers onto payroll—strengthening transparency and professional quality assurance at the point of workforce entry.

[3] https://cgatechnologies.org.uk/projects/sierra-leone-teacher-management-information-system-tmis

[4] https://cgatechnologies.org.uk/projects/strengthening-education-systems-sierra-leone-sessl-teacher-records-mis-and-hr-manual

4.3 Stage 3: National school data: Establish a single master list and common data framework

A coherent **national school master list**—where every school is assigned a unique ID and key data fields on location, ownership type, and education levels taught are recorded—underpinned by a **common data framework** serves as an essential backbone for education planning, spending, and accountability (van Wyk and Crouch, 2020; Abdul-Hamid, 2014).

Countries that institutionalize a national school master list with unique cross-government school codes and geo-coordinates can target resources, identify new and 'ghost' schools, and link school-, teacher-, and learner-level datasets for system-wide analysis. Where this foundation is missing, education services become fragmented; different organizations count schools differently, leading to disjointed targeting of resources, allocation of staff, and delivery of capitation grants, leaving some underserved.

A common data framework extends this foundation by establishing consistent definitions, data standards, and protocols across ministries and partners. Even where data systems remain fragmented, agreeing on a common data framework provides potential for interoperability and analysis across datasets. Without registry discipline, attempts at deeper analysis and performance management are unstable with weak data assurance (van Wyk and Crouch, 2020; Abdul-Hamid, 2014).

Establishing such a system requires consistent investment of time and resources. Governments must verify and approve schools, while also considering the number of schools run by non-government (e.g., religious) networks. This database should then be maintained as a dynamic system rather than a static file.

As identified above, one-off snapshot verification exercises typically only show the situation on a single day, rather than the reality of who is present in the school and which resources are deployed over time, thereby misrepresenting the true state of schools or staff and providing unreliable data for system management. Sustainable school data management means embedding regular updates into administrative routines as part of running a school, not a separate project.

A recurring finding across EMIS deployments is that technically functional systems can fail to generate usable management information: data are collected but not analyzed; dashboards are built but not consulted; systems are maintained during project funding periods and then abandoned. Van Wyk and Crouch (2020) document these failures directly, noting that even well-resourced EMIS investments frequently produce outputs that ministries neither trust nor act upon. The primary causes are institutional rather than technical—weak incentives for data use, low analytical literacy among decision-makers, and political disincentives to transparency where accurate data would expose misallocation.

The risk is that investment in Stage 3 produces inert infrastructure rather than the trusted, interoperable data that Stage 5 requires. When a teacher MIS is linked to the payroll, it generates fiscal pressure, and therefore impact: verification has financial consequences. That condition is not present by default and must be explicitly built in rather than assumed to follow merely from the existence of a data system.

Once a reliable master list and common data framework are in place, countries can confidently link datasets and create a single, authoritative source of truth. Only then can planning directorates align supply-side inputs (schools, teachers, subventions, capitation grants) with demand-side needs (learners, enrollment patterns) and identify where the system is falling short.

Stage 3 Examples:

School Data in Practice

The academic case for Stage 3 rests substantially on older evidence about what happens in its absence. Reinikka and Svensson (2004) found that Ugandan primary schools received on average only 13% of their capitation grant entitlement during 1991–95, with the remainder captured at district level. The proximate cause was an absence of the conditions Stage 3 is designed to create: no verified school register, no transparent entitlement data, and no cross-ministry accountability mechanism. Similar issues have also been identified in Tanzania and Ghana, where public expenditure tracking surveys conducted subsequently found leakage rates of 41% and 50% respectively (Gauthier, 2010, as cited in Reinikka and Svensson, 2011).

The Ugandan government addressed the issue by publishing grant disbursement data in national newspapers, reducing district-level capture to below 20% by 2001, with associated gains in enrollment and learning outcomes (Reinikka and Svensson, 2011). The mechanism—verified data enabling accountability—is precisely what a functioning school master list and common data framework is designed to institutionalize.

Kenya – National Education Management Information System (NEMIS) and cross-ministry data use

Kenya's National Education Management Information System, launched in 2018, assigns every school a mandatory unique four-character code and every learner a Unique Personal Identifier that travels with them across institutions (GPE, 2017). The system connects the Ministry of Education, the Teachers Service Commission, and the National Treasury, enabling capitation grants to be calculated against verified enrollment, teacher deployment to be checked against actual school population, and textbook procurement to be planned from a single data source (Kenya MoE, 2023; GPE, 2017).

A 2025 special audit found ghost schools had fraudulently received KES 3.7 billion in capitation—auditors reported they could not find these schools on the ground (Auditor-General, 2025). A technically functional system, without sustained data validation and financial accountability mechanisms, drifts toward the same failures as no system at all. Stage 3 requires not only construction but robust accountability processes, maintenance and effective management.

Counter-example: Ghana – systems without a common framework

Ghana illustrates the specific failure that Stage 3 is designed to prevent: data collected but unable to travel across the system. As of Ghana's 2023 GPE Partnership Compact, EMIS data and national examination data remained unconnected because schools were not identified by the same unique codes (GPE, 2023). The Ministry acknowledged dependence on development partners for evidence to support critical decisions on learning outcomes. UNICEF's 'Data Must Speak' program identified the absence of unique school identifiers as a primary barrier and initiated a specific intervention to create them (UNICEF Innocenti, 2024). Ghana's Mobile School Report Card, deployed to improve school-level data, has very limited use in official policy making at regional or national levels, functioning primarily as a data repository (UNICEF Ghana, 2019).

The contrast found in how effective these initiatives are is the result of structural design factors and ensuring supportive processes and management are in place, rather than there being a shortfall of effort or investment. Ghana has functional data systems; Kenya has a common data framework. Only the latter enables the cross-ministry resource allocation—capitation, teacher posting, infrastructure investment—that Stage 3 is designed to support.

4.4 Stage 4: Decentralize management: Empower mid-tier officials to use data and support schools

Local government education offices—whether district, county, or state—and the officials within them are the system's critical interface between national ministries and schools. They are the first line of management and the last point of accountability before the school itself. When equipped with the right digital tools, data, resources, and mandates, these offices may more effectively manage their schools, monitor performance, support school leaders and teachers, and diagnose and resolve barriers to delivery (Tournier et al. 2025; Jain & Bergmann, 2026, p. 19).

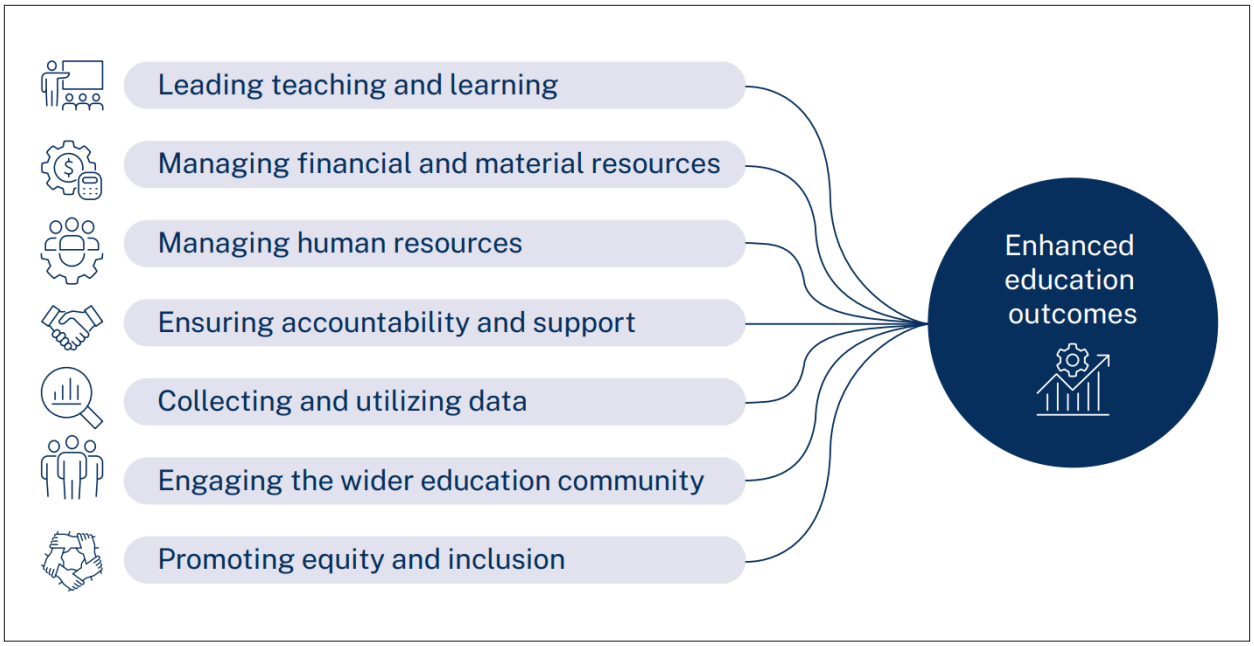


FIGURE 5 TOURNIER ET AL (2025) THE ESSENTIAL ROLES REGIONAL OFFICIALS PLAY IN ENHANCING EDUCATION OUTCOMES THAT WITHOUT ARE MORE CHALLENGING TO DELIVER.

Empowerment

Decentralization of budgetary control and influence is required to engage local government. The most common and effective way to deliver this is control over teacher workforce. In their discussion of the correlation between education and corruption, Konte identifies correlation between corruption perception and quality of schooling, leading to a requirement for accountability (2021). When in place, the effects can be stark: Ceará, despite being one of Brazil's poorest north-eastern states, has achieved one of the lowest learning-poverty rates in the country. This performance reflects a package of decentralization-aligned reforms, notably results-based financing and sustained technical support to municipal education boards (Loureiro et al., 2020), and it has informed similar quality-improvement programs in other Brazilian states (Azevedo et al., 2021).

The evidence from Ceará and comparable contexts suggests that sustainable transformation requires devolving budgetary control alongside responsibility to the place where the information and solution is best understood.

Equipping Regional Offices to Act

In order to take action, regional offices need appropriate tools to be able to act. Every education office should function as an information node—equipped with computers and connectivity, enabling school leaders and teachers to access digital resources, and staffed by district education teams themselves trained to interpret and act appropriately on data.

Developing data capability requires more than training alone. Officers need practical tools, dedicated time, and budget allocations to collect, analyze, and make data-driven decisions. Structured support—through mentoring, peer learning networks, and integration of data tasks into job descriptions—helps embed a culture of evidence-based management. Regions must help schools manage hardware and training for EdTech to deliver at scale; when education offices cannot train, troubleshoot, or hold end users accountable then the teaching and learning materials, resources, infrastructure, and the teachers themselves will not be deployed to their greatest effect.

Bolstering regional digital capacity also encourages increased teacher presence in the classroom. Without it, teaching time is often wasted travelling to headquarters to complete administrative functions and manage careers. By enabling teachers to complete these processes, such as apply for leave or submit forms, at regional education offices rather than national headquarters, they spend more time in the classroom, which directly impacts learning outcomes (Bold et al., 2019).

Vulnerability to local capture

While decentralization localizes opportunity, it does carry risks. Bardhan and Mookherjee (2006) demonstrate formally and empirically that local governments, while more responsive to citizen needs than central bureaucracies in some respects, are substantially more vulnerable to capture by local elites. Where social and economic inequality within communities is high, evolved resource allocation tends to favor elite households, reproducing rather than reducing inequality in service delivery.

Their analysis finds that the welfare impact of decentralization is contingent on the relative degree of capture at local versus central levels: in high-inequality, low-accountability contexts, decentralization can be Pareto-inferior to centralization. In education, teacher posting, school resource allocation, and capitation grant distribution are all susceptible to local political interference when control is devolved without accompanying accountability mechanisms. This framework requires robust accountability mechanisms in Stages 2 and 3 to protect against this risk.

These findings underline the importance of designing EdTech deployment within governance arrangements that actively guard against elite capture and ensure that resources, hardware, and decision-making power are not disproportionately steered toward already advantaged households.

Stage 4 Example:

NB: Rigorous examples of Stage 4 in the literature are relatively few. The below example highlights that devolving resources closer to schools is only effective when paired with accountability, underscoring the need to invest in district-level education management, not bypass it.

Tanzania – KiuFunza: when decentralized resources meet accountability
Mbiti et al. (2019) conducted a pre-registered RCT across 350 public primary schools in Tanzania's KiuFunza program, testing whether direct school grants, teacher performance incentives, or their combination improved learning outcomes over two years. Schools receiving grants alone showed no measurable learning gains despite the funds reaching school accounts and increasing expenditure; incentives alone were similarly ineffective. Only the combined group—grants paired with bonuses tied to learning outcomes—produced meaningful gains of 0.23 standard deviations, at a cost of approximately US$13 per student per year.

The null result from grants alone is an instructive finding. Resources reached schools, bypassing the district councils responsible for historical leakage of roughly 40% of capitation funding, yet teacher behavior did not change and learning did not improve. Beasley and Huillery (2017) found a near-identical pattern across 1,000 schools in Niger: school grants combined with committee training produced no learning gains and a perverse increase in teacher absenteeism, because parents with low literacy were unable to convert devolved authority into effective monitoring. Both studies indicate that resource devolution without accompanying accountability is ineffective.

Decentralizing fiscal control is a necessary but not sufficient condition for improved outcomes: the mechanism only activates when resource devolution is paired with performance accountability that local actors can observe and act upon. The Tanzanian government shifted to direct-to-school grant disbursement in 2016, but the experimental evidence suggests that this structural reform delivers its full return only once the data systems, trained staff, and incentives suggested in Stage 4 are in place.

4.5 Stage 5: School management: Use data and support teachers

Once district government offices are equipped with tools, connectivity, and capacity, the next step is to empower schools and school leaders. Schools should digitize core administrative functions (enrollment, attendance, assessment, staff records) and **use** these data for their own management and decision making. The evidence reviewed here suggests school data should not simply be reported 'up' and, while it could be said that many school leaders run schools effectively using hard-copy paper records, this constrains other decision-makers from sharing that same understanding of the school's performance or needs.

Many school leaders are alone in their knowledge of key resource gaps and yet also lack the authority to make necessary changes. Re-empowering them (following the centralization of salary payments) with accurate and timely data and the ability to report resource gaps enables them to lead instructional improvement and hold their own teachers better accountable (Romero et al., 2020). Where large proportions of the teaching workforce are unpaid, and qualified teachers are insufficient in number to meet demand, every day a class teacher is absent represents lost learning time. Data on attendance and performance allows leaders to respond quickly, coach effectively, and build a culture of shared responsibility for outcomes. Effective school leaders turn data into well-reasoned action, and ministries can empower them to do so (New Leaders Foundation, 2026).

Teacher acceptance model (TAM) meta-analyses in Scherer et al. (2019) consistently find that the intention behind digital technology adoption outperforms actual sustained use. Teachers who express positive attitudes toward technology in surveys frequently revert to prior practices once researcher attention is withdrawn. Scherer et al.'s structural equation modelling of 114 studies finds that perceived usefulness and ease of use predict intention reasonably well, but that sustained classroom integration depends on factors—institutional support, preparation time, pedagogical fit, and technical reliability—that are precisely the system conditions absent in low resource settings.

Teacher digital literacy training without concomitant changes to workload, infrastructure reliability, and curriculum integration is likely to produce temporary rather than sustained adoption. The practical implication for implementation design is that training must be accompanied by structured follow-up, reduced administrative burden, and reliable device functionality. Training alone is insufficient without structural adjustments.

Digital Literacy as a Precondition, Not an Afterthought

Without foundational investment in teacher digital literacy, deploying devices in classrooms yields negligible returns. Hardware without pedagogical capability is an inert resource; the sequencing matters. Sustainable integration of technology into teaching practice requires that teachers are trained before devices arrive, not alongside or after.

Teachers Before Learners

The teacher is the most consequential school-level input into learning outcomes. Variation in teacher effectiveness is wide and is not well explained by observable characteristics (Jackson et al., 2014); what this implies for EdTech sequencing is direct—the returns from classroom technology are mediated through teacher capability, and interventions that circumvent this channel tend to fail.

In Zambia, Impact Network trialed its eSchool 360 program for technology-aided instruction in 63 schools through a quasi-experimental design. The intervention included structured lessons on tablets, teacher training and coaching, community ownership structures, and removal of fee barriers. De Hoop et al. looking at the

eSchool 360 Model found significantly improved reading (+0.40 standard deviations (SD)) and math (+0.21 SD). The success of this initiative is perhaps explained in that it consists of technological investments embedded in a broader package combining governance and pedagogy, representing a broader framework of reform rather than technological investment in a vacuum.

Beg et al. (2020) used two RCTs in Pakistan to show that expert-led curriculum videos integrated into classroom teaching raised student test scores significantly by 0.3 SD after four months—at a cost of US$9 per student. The same content delivered to students on personal tablets reduced scores by 0.4 SD at US$131 per student. The contrast represents a near-full standard deviation difference driven largely by changes in teacher effort and practice, rather than the content itself. This is consistent with Muralidharan et al. (2019), who find large gains from well-designed technology-aided instruction in India—but only where pedagogical design is explicit and structured. PISA data show that simple exposure to digital technologies in education is not associated with improved student learning, highlighting the importance of teacher mediation and training (OECD, 2023b).

Bold et al. (2019) find, across seven sub-Saharan African countries, that teacher content knowledge deficits are a primary driver of learning gaps. Technology deployed through teachers—rather than around them—can begin to address this by raising the pedagogical floor, modelling grade-appropriate instruction, and building Information and Communications Technology (ICT) confidence through use. This last point matters: teacher digital capability is not a precondition for all EdTech deployment, but it is a precondition for sustaining it. Systems that invest impactfully in teacher-facing technology first build the human infrastructure on which learner-facing technology can later scale.

Leveraging Existing Government Data Infrastructure

Many education sector initiatives overlook a significant and largely untapped asset: government data systems and their network of users with varying roles and responsibilities. If properly utilized, these systems and networks can dramatically extend the reach and efficiency of development programs, such as the example of the Girls in School Initiative (Graham et al., 2025). Rather than commissioning parallel monitoring architectures or standalone assessments, partners should integrate with these systems and seek to utilize this important network of users and stakeholders from the outset.

The case for doing so rests on four interdependent rationales. First, it eliminates redundant expenditure. Standalone assessments and resource-intensive project-specific monitoring frameworks divert scarce capital away from direct program delivery; integration removes this drag. Second, it creates a replicable model. A framework built on government systems is inherently scalable and available for adoption by other education partners, reducing duplication across the sector, providing government oversight capability and reinforcing durable national capacity. Third, and most consequentially, it aligns partner resources to sovereign priorities. When investment flows through government systems rather than around them, interoperability compounds returns—each dollar goes further, and the structural inequalities that fragmented programming tends to entrench are, over time, reduced. Finally, it enables strategic gap-filling: knowing where education partners are working—and where they are not—prevents duplication and helps ensure that the most marginal areas and learners do not fall through the cracks.

Where schools have the incentive, authority, and opportunity to act, they do; but if they cannot manage their staff, infrastructure, or devices, learners cannot effectively benefit from EdTech.

Stage 5 Example:

Sierra Leone and HereMIS – counting every child

Sierra Leone's Wi De Ya system (We Are Here in Krio, developed for Sierra Leone from CGA Technologies' HereMIS education attendance monitoring platform) illustrates what becomes possible when school management infrastructure precedes learner-facing technology. Commissioned by the TSC and Ministry of Basic and Senior Secondary Education (MBSSE), and developed by CGA Technologies under World Bank funding, Wi De Ya deployed one Android tablet per school to capture twice-daily teacher and learner attendance data, synchronized to a central cloud database linked to the TSC's Teacher Records Management, payroll, and TMIS.

The system's value is not in the tablet itself, it is in the verified, near-real-time data it produces. At Stage 5, those data serve three compounding functions. First, they enable the head teacher to manage their school; daily attendance registers replace informal record-keeping and create an auditable basis for professional accountability. Second, the data enable district TSC and MBSSE officials to monitor compliance, identify schools requiring support, and target teachers for structured training—uses that are impossible where school-level data either does not exist or is not trusted. Third, they make the data available to partners operating within government systems.

This third function is where the multiplier effect becomes visible. Corus International's Girls In School Initiative (GISI), implemented by CGA Technologies from 2024, uses Wi De Ya data to identify vulnerable girls meeting program criteria (overage learners, adolescent mothers, girls with special needs, and former out-of-school children) and to monitor their attendance as the basis for lightly conditional monthly cash transfers. Preliminary findings from Year 1 (2024/25), covering 14,938 learners across 28 primary schools, indicate that participating girls maintained attendance approximately four percentage points above both the control group and the all-learner average from January to April; cash transfers further prevented the pronounced third-term attendance decline observed in the control group (CGA Technologies, 2025; Graham et al., 2025).

In this case, the program was enabled by the established school management tool, Wi De Ya. The attendance data underpinning GISI's targeting, monitoring, and case management did not require a new system; it required that an existing government system was operational, trusted, and interoperable. The tablet in the headteacher's hand produced the data to target a vulnerable population. This demonstrates how development partners can strengthen systems even when that is not the core objective.

4.6 Stage 6: Classroom technology, last, not first

UNESCO's 2023 Global Education Monitoring Report cautions that EdTech impact remains mixed while costs are routinely underestimated. The position of this paper is that technology's most impactful contribution lies in working to enhance pedagogy and advance equity, rather than to displace teachers. The evidence reviewed here suggests classroom technologies are unlikely to scale sustainably unless the systems beneath them are established: power, connectivity, payroll and HR data, EMIS, and local administrative capacity. Targeted low-tech, own-device approaches (phone tutoring, SMS) can deliver cost-effective gains even before all foundations are in place, though sustainability at scale appears limited. Devices-first strategies without these underpinnings rarely produce system-wide learning improvements.

This is not an argument for stasis or for letting the 'best' be the enemy of 'good' in considering how to modernize. Rather the issue at hand is how to do so without compounding existing challenges and further entrenching inequity. Srholec (2011) observed that African firms are constrained in their capacity to absorb and generate new technology, though the structural conditions underpinning that finding have shifted considerably. What has not shifted is the competitive pressure: barriers to quality education have reduced, but international competition to capture technological advantage has intensified. The risk for late-integrating systems is not irrelevance but exclusion, as national workforces race to build the skills required to operate in an increasingly technological economy.

Robust trials in remote, off-grid communities and refugee camps show that solar-powered, offline tablets can deliver foundational learning gains as a parallel or supplemental provision: for example, the Tanzania XPRIZE villages (Enuma, Inc., n.d.), Dzaleka and Nyarugusu RCT saw success (Imagine Worldwide, 2023 and Levesque et al., 2024, respectively). However, this review found no rigorous evidence that integration of a devices-first approach into fragile, low-resourced government classrooms scaled impact without prior investments in infrastructure, clean administrative data, national school IDs, and decentralized instructional support. Where there has been success in using classroom-level devices, the approach minimized system dependencies; where systems have succeeded at scale (e.g., Kenya, Tusome), devices held by government Curriculum Support Officers are embedded within structured pedagogy and feedback loops.

Angrist, Bergman and Matsheng conducted a Botswana phone tutoring RCT showing the scalability of EdTech with many of the foundations not in place, demonstrating low-tech gains are possible (2022), though at the time of implementation electricity access had already reached 73.70% (Musakwa, 2024). In addition, Pitchford's eight-week RCT in Malawi showed learning gains, though this was only in one urban school (2015). While there is evidence of the ability to learn digitally, these evaluations generally do not look at the relative cost of providing (nor the benefit of) the additional infrastructure, whether that is solar, or other.

Emerging evidence (though the programs are not directly comparable) states that AI digital learning programs could be generally more cost-effective than other EdTech programs (Alazemi, 2024) although, being a new area, more in-depth research is required.

Angrist et al. demonstrate that EdTech can support teaching at the right level, maximizing the potential of proven interventions (2023). Evidence from Click Learning's recent pilot comparing different classroom tools in South Africa (Schaefer, 2025) illustrates this challenge: despite strong pedagogical potential, usage rates were low on AI-tools because they required more than three times the available internet bandwidth. This result is repeated in emerging literature (Srinivasan and Murthy, 2021; Elifas and Simuja, 2024; Mohammed, 2025;

Hakimi and Shahidzay, 2024). Large devices-first rollouts without pedagogical or system supports produced null or negligible effects on academic achievement—no effects on math or reading scores were found in Peru after 15 months (Cristia et al., 2017) and this finding is repeated 10 years on (Cueto et al., 2025). Nor were positive results found in Uruguay after two years of national implementation (de Melo et al., 2014). It is worth highlighting that neither project had compulsory teacher training.

Classroom technology delivers its full promise only when built upon stable systems that ensure teachers are supported, schools are connected, and digital tools are both accessible and sustainable. Beg, Lucas, Halim and Saif (2020) show that teacher-mediated tech improved learning by +0.3 SD, while bypassing teachers with personal tablets reduced scores by –0.4 SD (these are educationally meaningful values). Therefore, at absolute minimum, one tablet, one computer, or one phone at the school level reflects critical progress and can have transformative impact if underpinned by prior infrastructure. Similarly, a device provided at classroom level for use by the teacher with a supportive pedagogical and management framework can significantly improve learning outcomes.

Stage 6 Examples:

Kenya – three models, same children, different answers

Kenya offers a natural comparison: three technology-related interventions targeting the same primary school population, implemented in a similar timeframe.

1. **The Digital Literacy Program** (DLP) distributed approximately 1.2 million tablets to Grades 1-3 across 21,637 public schools from 2016 at an estimated cost of KES 30 billion (roughly US$296 million). It provided training to only one third of rural teachers and conducted no independent evaluation of learning outcomes; parliamentary testimony and field assessments found most tablets unused or missing (Omito et al., 2019). Like Peru's OLPC, it was a high-cost and high-visibility device distribution that bypassed Stages 2-5. Due to the lack of integrated assessment, it left no measurable learning footprint. Piper et al. (2015) warned the success of Kenya's laptop initiative "will depend largely on the integration of the initiative into the realities of classroom instruction."

2. **Kenya's Primary Math and Reading (PRIMR) Initiative's** ICT arm provides the experimental evidence the DLP lacks. Piper et al. (2016) conducted an RCT comparing e-readers for pupils and tablets for teachers against a base structured pedagogy program with no classroom devices. ICT additions produced no significant learning gains beyond structured pedagogy alone; an additional US$100 spent on hardware produced 15 fewer pupils reaching national benchmarks than the same amount spent on pedagogy.

3. **Tusome** (2015-present) scaled PRIMR's structured pedagogy model to 7.2 million learners across all public primary schools, using tablets only for Curriculum Support Officers conducting coaching visits. External evaluation found effect sizes of 0.6-1.0 SD for literacy—among the largest gains documented by any national program globally (Piper et al., 2018). The system conditions underpinning this were Stages 2-5 in practice: verified payroll enabling coach deployment, a functioning decentralized middle tier of Curriculum Support Officers, and school-level feedback loops—all in place before any learner-facing technology appeared.

Ghana's Making Ghanaian Girls Great (MGCubed) achieved gains of 0.21-0.33 SD through solar-powered, satellite-broadcast interactive instruction with local facilitators—a significant change (Johnston and Ksoll, 2022). However, its fixed satellite infrastructure and dependence on an external broadcast studio render it unsuitable for national classroom integration until the underlying system architecture is in place to absorb it. It is a supplemental bridge model, not a scalable alternative to completing the preceding stages.

The comparison is direct: technology deployed ahead of the system produced nothing; technology embedded within a system built on structured pedagogy and middle-tier accountability produced transformative gains; and technology designed to bypass the system can work at small scale but cannot scale without it.

5 Planning considerations

Successful implementation of this six-stage framework requires attention to cross-cutting factors that influence how each stage unfolds in practice. While the stages provide a logical sequence for education technology deployment, three critical considerations—AI, sustained focus, and data governance—cut across all stages and require deliberate planning from the outset. This section identifies these challenges and opportunities.

Artificial Intelligence. The world is already AI-enabled, presenting an opportunity to build more effective teaching and learning processes and tools for the next generation. While guarding against the risks, every feasible and acceptable opportunity to improve the classroom should be taken. AI changes how data are built, understood, and used. It changes how classes can be planned, how individual learning plans can be developed, and how learners understand technology. People will use AI tools to achieve efficiencies and, hopefully, to enhance outcomes at each stage of this framework, this framework may be as applicable to AI in classrooms—a particular area of focus among AI actors—as other EdTech investments. That is, such programs are still assumed to rely on some or all of i) quality data sets, ii) infrastructure, and iii) teachers in order for tools to be accessible, learning to take place, and outcomes to be achieved.

Other use-cases, such as the application of Large Language Models (LLMs) to education data interpretation, carry particular risks such as hallucination based on their probabilistic nature. While work is being done on contextual knowledge, for now African data are a limited proportion of the training data. While this can offer a useful analytical function, to untrained users, LLM outputs are plausible-sounding and difficult to verify without the domain expertise that is scarce across ministries. There would need to be careful guardrails to ensure that data with no factual basis would not be relied upon for fiduciary decisions.

The sequencing logic of this framework applies to AI as to any other technology. Deploying AI tools without clean data, trained users, and verification mechanisms—the outputs of Stages 2 to 4—is likely to generate confident but unreliable outputs, with consequences more difficult to detect than a broken tablet. Academic uptake of AI in low-income countries is less than a fifth of in high income countries (García Ramos and Wilson-Kennedy, 2024). Frontiers research published in 2025 examining AI applications in LMICs concludes that without reliable electricity, adequate infrastructure, and foundational teacher training, AI adoption risks deepening educational inequality rather than reducing it (Kohnke and Zaugg, 2025).

Effective data use by policymakers and other stakeholders remains a challenge. LLMs can help, but it can require significant expertise to distinguish between correct interpretation and AI hallucination. This expertise needs to be built quickly, underpinned by standards and guidance, if the benefits of AI in teaching and student outcomes are to be realized as part of this wider strategic approach.

Sustained focus. Persistence and sustained focus over long periods are essential in implementing this framework if civil servants are to grow comfortable using these stages in practice and interpreting the information they generate. Timelines should be 3-10 years for implementation—shorter term focus may create an effect, but it is more likely to be temporary. As systems improve, ministries must bring skillsets up to meet the current process and be capable of developing the next process, but this takes consistency in the administration of civil service alongside the continuous support of external actors.

Data Governance. This represents a growing risk for governments but even more so for citizens. As governments digitize teacher records, attendance data, and learner identifiers across Stages 2–5, they simultaneously create datasets that hold the potential for significant commercial value. UNICEF Innocenti's 2025 landscape review on data governance for EdTech finds that education ministries frequently lack the expertise to assess EdTech platforms or negotiate equitable data-sharing agreements, and that companies are

rarely required to be transparent about how they use data collected in schools (UNICEF Innocenti, 2025). The risk is compounding: LLMs can memorize and reproduce personally identifiable information from their training corpora, including names, locations, and institutional identifiers (Das, Amini and Wu, 2024). Where education data is hosted on commercial platforms without contractual restrictions on secondary use, records generated under this framework risk being scraped and monetized without the knowledge or consent of those concerned.

The regulatory environment offers limited protection. The African Union's (AU) Malabo Convention entered into force only in June 2023, and none of Africa's largest education systems—Nigeria, Kenya, South Africa, Ethiopia—have ratified it; its provisions make no specific reference to education data or children as data subjects (Chatham House, 2024). The AU's Continental AI Strategy (2025–2030) acknowledges that privacy risks disproportionately affect children, but enforcement mechanisms remain nascent (Future of Privacy Forum, 2025). Populations with low digital literacy—the majority of teachers and parents in these contexts—cannot meaningfully consent to data processing, the implications of which they are unable to assess.

The implication is that data governance cannot be deferred to Stage 6. Governments establishing digital systems at Stages 2-5 should, from inception, define data ownership, restrict secondary use contractually, require local hosting where feasible, and establish audit trails for third-party access. The UNICEF Innocenti policy recommendations for child-rights-by-design in EdTech procurement offer an actionable starting point (UNICEF Innocenti, 2025). Without these protections, the digital infrastructure this framework advocates becomes a mechanism for extracting value from the populations it is intended to serve.

6 Conclusion

6.1 A practical sequencing framework

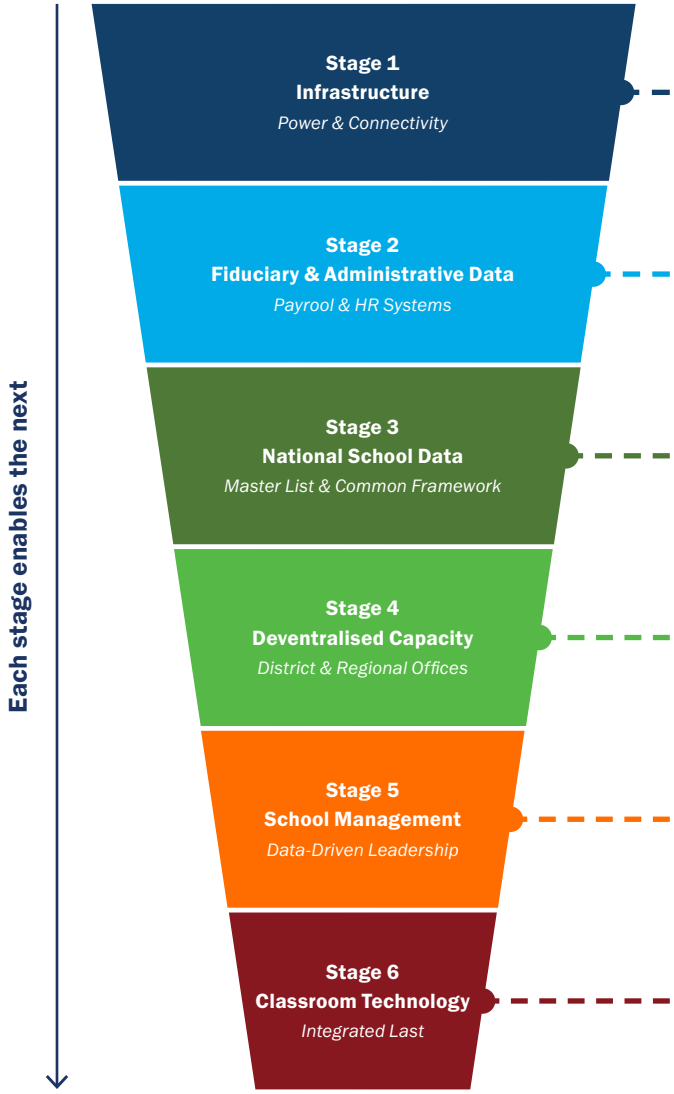
The six stages presented here form a cumulative architecture in which each stage creates the structural conditions the next requires.

- Stage 1: power and connectivity is the non-negotiable base; without it, no electronic system can function at any level of the education hierarchy.
- Stage 2: digitizes and audits teacher payroll and HR records, because teachers constitute the largest share of education expenditure and no workforce can be managed, deployed, or held accountable without a reliable and verified record of who is employed and where.
- Stage 3: establishes a national school master list and common data framework, giving every institution a unique cross-government identifier and creating the interoperability that makes system-wide resource allocation and accountability structurally possible.
- Stage 4: devolves the capacity to act on that data to district and regional offices, equipping the middle tier with tools, connectivity, trained staff, and a meaningful mandate—without which national systems remain permanently disconnected from schools.
- Stage 5: brings data-driven management to the school itself: digitizing attendance and assessment, building school leaders' capacity to act on data, and establishing teacher digital literacy before any learner-facing technology is introduced.
- Stage 6: deliberately last, integrates classroom devices, platforms, and content with fully costed operations in place—because the evidence reviewed indicates that classroom technology deployed without the five preceding foundations produces null or negative returns on investment.

Sequencing EdTech for Impact

Six Non-Negotiable Stages in Sustainable Education Technology Reform in Sub-Saharan Africa

Author | Education Systems Strengthening Framework



Stage descriptions

Infrastructure: Power & Connectivity
Reliable electricity and network access at school and district level. Without dependable power no subsequent digital reform is possible at scale.

Fiduciary & Administrative Data
Digitised, auditable teacher playroll and HR records with unique identifiers. Confirm who is employed, where they serve, and that they are real.

National School Data
Single authoritative school registry with unique IDs, geo-coordinates, and interoperable data standards. Single source of truth for planning and resource allocation.

Decentralised Capacity
District offices equipped with tools, connectivity, and mandate to manage schools and act on data. Devolve budgetary control alongside responsibility.

School Management — Data-Driven Leadership
School leaders use real-time attendance and performance data to manage and support teachers. Digital literacy embedded before devices arrive.

Classroom Technology — Integrated Last
Devices, platforms, and content deployed only when all underlying systems are in place and sustained. Technology amplifies; it cannot substitute foundations.

Cross-cutting factors throughout all stages:

Artifical Intelligence | Sustained institutional focus | 3-10 year implementaion horizons

Note: Sequence describes dependencies for efficient action, not preconditions for parallel activity.
Limited leapfrogs (e.g. mobile vs fixed connectivity; solar vs grid) can accelerate progress but do not replace foundational requirements.

6.2 Next Steps: From Framework to Implementation

The six-stage framework proposed in this paper provides a structured hypothesis for how governments, donors, and implementing partners can sequence investments to deliver sustainable EdTech reform. Improvement by researchers on the claims made here with heavy inference would be welcomed and could serve to guide a resource constrained sector in the brave new world.

It is hoped that policymakers can use this practically to: (1) establish whether minimum viable progress has been made for each stage before switching focus, (2) align financing between organizations and with the readiness of the state, (3) prepare data stewardship performance mechanisms.

Any shift from principle to practice in employing this framework requires intentional, long-term planning aligned with political economy realities and the resource constraints of low-income systems. However, what is demonstrated by the examples throughout this paper is that where ambition is framed within sound planning and adherence to this rationale, EdTech initiatives can have transformative, positive impact on learners and learning outcomes across the Global South.

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8 Annex 1. The Sequencing Framework Table

Stage	Objective	Key Evidence	Consequences if Bypassed
Stage 1 ***Establish infrastructure: power & connectivity***	Ensure schools have dependable electricity and internet connectivity as the foundational prerequisite for all subsequent EdTech reform. Leapfrogs permitted: solar, generators, power banks, offline-first apps—but these are interim measures, not substitutes for systemic infra-structure.	• ~600 million Africans (40%) lack electricity; universal access by 2030 requires ~US$25bn/year (IEA, 2024, 2025). • Electrifying schools linked to improved HDI education index (Kanagawa & Nakata, 2008); 83% of parents reported improved education experience post-electrification (Pierce, 2022). • 89% of Africans within mobile coverage, but only 30% use mobile internet—the largest usage gap globally (GSMA, 2024). • Mission 300 (World Bank/AfDB) targets 300 million newly connected by 2030; a further 300 million would remain unconnected (AfDB, 2025).	• Devices cannot charge or run. • Networks cannot connect; data systems cannot operate. • Every subsequent stage is stalled or unscalable. • Programmatic workarounds (solar, generators) carry higher per-user cost and do not enable systemic digital transformation.
Stage 2 ***Digitize fiduciary & administrative data systems***	Digitize and audit teacher payroll and HR records with unique identifiers; link payroll, HR, and EMIS before any broader workforce or technology reform.	• Teachers constitute the largest public-sector workforce and the highest share of education recurrent expenditure—often exceeding 100% of recurrent budgets in LMICs (OECD, 2025; Zymelman et al., 1988). • In Sierra Leone, 43% of teachers in government-supported primary schools are not on the official payroll (CGA, 2023). • Teacher management has a more reliable impact on education outcomes than in-service training (Hassan, 2022). • Digitized payroll systems reduce fraud, ghost workers, and fiscal leakage (Bwaki & Tefurukwa, 2022; Schreiber & Kenyah, 2018; Ayehu et al., 2026).	• Ghost workers persist; fiscal resources misallocated. • Workforce planning is impossible without reliable headcount. • EMIS, dashboards, and analytics built on corrupted HR data produce unreliable outputs. • Accountability and safeguarding risks increase.
Stage 3 ***Establish a national school master list & common data framework***	Assign every school a unique cross-government identifier and geo-coordinates; agree on consistent data definitions and standards across ministries and partners to enable interoperability.	• Without registry discipline, attempts at performance management and system analysis are unstable (UNESCO-UIS EMIS guidelines; World Bank SABER-EMIS). • Different organizations counting schools differently leads to disjointed resource allocation, capitation grant errors, and gaps in service delivery. • A dynamic, continuously updated master list is required; one-off verification exercises are outdated immediately and misrepresent system reality.	• Ghost and unregistered schools persist; resources are misallocated. • Supply-side inputs (teachers, grants, infrastructure) cannot be aligned to demand-side needs (enrollment, learning gaps). • Cross-government data linkage is impossible, preventing any meaningful system-wide analysis. • Subsequent EMIS and analytics investments are built on unreliable foundations.

8 Annex 1. The Sequencing Framework Table cont.

Stage	Objective	Key Evidence	Consequences if Bypassed
Stage 4 ***Strengthen decentralized capacity for management & support***	Equip district and regional education offices with digital tools, data access, budgetary mandate, and trained staff to act as effective information nodes and accountability intermediaries.	• Middle-tier officials are the critical interface between national policy and school delivery; their capacity directly determines whether national reforms reach classrooms (Tournier et al., 2025; Jain & Bergmann, 2026). • Ceará (Brazil): results-based financing and sustained technical support to municipal education boards produced the country's lowest learning-poverty rates despite being among its poorest states (Loureiro et al., 2020). • Administrative travel to national HQ displaces teacher classroom time; devolving functions to regional level directly improves learning outcomes (Bold et al., 2019).	• National systems remain disconnected from schools. • EdTech cannot be deployed, troubleshot, or sustained at scale without local technical capacity. • Teacher absenteeism and HR issues go unaddressed; accountability is absent. • Hardware distributed to districts cannot be main-tained, rendering it inert.
Stage 5 ***Develop data-driven school leadership & teacher support***	Digitize core school administration (attend-ance, assessment, staff records); build school leaders' capacity to use data for instructional improvement and teacher accountability; establish teacher digital literacy before learner-facing devices are introduced.	• Engaging teachers with technology raised student achievement; bypassing teachers did not—a near-full SD difference at 14x lower cost (Beg et al., 2020: +0.3 SD at US$9 vs. −0.4 SD at US$131 per student). • PISA data: simple exposure to digital technology is not associated with improved learning without teacher mediation (OECD, 2023b). • Sierra Leone Wi De Ya/HereMIS: verified, near-real-time attendance data enabled targeted cash transfers to vulnerable girls, sustaining attendance ~4 percentage points above control group (Graham et al., 2025; CGA Technologies, 2025). • Teacher content knowledge deficits are a primary driver of learning gaps across seven sub-Saharan African countries (Bold et al., 2019).	• Classroom technology deployed without pedagogical support produces null or negative learning effects. • No data infrastructure exists to target vulnerable learners or monitor program impact. • Investment in learner-facing devices at Stage 6 is wasted without the human infrastructure built here. • School leaders cannot manage teachers or diagnose barriers without timely data.
Stage 6 ***Integrate classroom technology—last, not first***	Deploy learner-facing devices, platforms, and digital content aligned to teacher competency frameworks, with fully costed operations, technical support, and sustainability plans in place.	• UNESCO GEM Report (2023): EdTech impact remains mixed; costs are routinely underestimated; technology must enhance—not displace—teachers. • Peru OLPC and Uruguay Plan Ceibal: large devices-first rollouts without system supports produced null academic effects. • Tanzania XPRIZE (n=2,400; 15 months) and Malawi/Tanzania refugee camp RCTs: significant gains achieved only where power/connectivity dependencies were fully engineered out (Enuma, n.d.; Levesque et al., 2024; Imagine Worldwide, 2023). • AI-enabled classroom tools failed at adoption in South Africa due to bandwidth requirements exceeding available infrastructure by >3x (Schaefer, 2025). • Where devices succeeded at scale (e.g., Kenya Tusome), they were embedded within structured pedagogy and feedback loops.	• Billions in investment lost annually on unsustaina-ble pilots (UNICEF). • Devices in unpowered or unconnected classrooms become inert assets. • Null or negative effects on learning outcomes where teacher mediation is absent. • Programs collapse once external funding ends, with no government system to sustain them.