

Impact of Digital Classroom Technologies on Learning Outcomes in Public Secondary Schools of Pakistan

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Abstract

Pakistan's public secondary education system faces persistent challenges, including low learning outcomes, high out-of-school numbers (26 million children), stagnant literacy rates (~60–61%), and pronounced urban-rural and gender disparities. This paper examines the impact of digital classroom technologies on learning outcomes, student engagement, teacher effectiveness, and system governance in public secondary schools. Empirical evidence from recent studies and the National Achievement Test (NAT) 2023 demonstrates that well-implemented ICT interventions interactive simulations, virtual labs, blended learning environments, Learning Passport platforms, and digital micro-schools significantly improve conceptual understanding, academic achievement (especially in science and mathematics), student motivation, and engagement, while reducing reliance on rote learning. Provincial initiatives reveal heterogeneous progress: Punjab leads in structured smart classrooms and teacher-centered technology provision, Sindh excels in decentralized models and accelerated digital learning for out-of-school children (particularly girls), Khyber Pakhtunkhwa advances online schooling and youth digital skills, while Balochistan remains severely constrained by infrastructure deficits. Despite promising results, widespread adoption is hindered by chronic barriers: unreliable electricity, poor last-mile connectivity, unaffordable devices, slow internet (only 21% rural access), limited teacher digital competency, and socio-economic inequalities. The paper argues that digital transformation holds transformative potential for achieving SDG-4 targets, narrowing learning poverty, and supporting girls' retention, but only if accompanied by strategic investments in infrastructure, continuous teacher training (TPACK-aligned), targeted equity measures, public-private partnerships, and data-driven governance reforms under frameworks such as NEPDF 2024 and Uraan Pakistan.

Keywords: Digital Classroom Technologies, Ict Integration, Public Secondary Education, Learning Outcomes, Student Engagement, Digital Divide, Teacher Digital Competency, Learning Passport, Blended Learning, Pakistan Education Policy, Sdg-4, Provincial Education Reforms, Out-Of-School Children, Gender Equity In Education.

1. Introduction

The educational framework of Pakistan is currently navigating a period of profound transition, moving away from traditional, teacher-centric models toward a technology-integrated paradigm intended to address chronic systemic failures (Rehman et al., 2024). The contemporary landscape is defined by an urgent "Education Emergency," as declared by the Prime Minister, a response to the 26 million children who remain out of school and a national literacy rate that has stagnated at approximately 60 to 61 percent (PIE, 2024). In this context, digital classroom technologies are no longer viewed as luxury interventions for elite institutions but as indispensable tools for human capital formation, poverty alleviation, and the cultivation of an enlightened, productive citizenry (Ministry of Federal Education and Professional Training, 2017). Public secondary schools, which serve as the final gateway to either the professional workforce or higher education, are the primary focus of these reforms. The integration of Information and Communication Technology (ICT) is strategically positioned as a catalyst for achieving Sustainable Development Goal 4 (SDG-4), which mandates inclusive, equitable, and quality education (Jamil & Khan, 2024).

2. Policy Landscapes and Governance Architectures

The evolution of digital education in Pakistan is anchored in a sequence of national policy documents that have increasingly prioritized technological integration (Ganaie et al., 2025). The National Education Policy (NEP) of 2009 initially articulated the need for a standards-based education system, emphasizing that the quality of instruction in government-owned institutions must be elevated through rigorous benchmarks for learners, teachers, and curriculum (Burton et al., 2023). This foundational vision was expanded in the draft National Education Policy 2017, which recognized that the era of information technology and globalization had fundamentally altered the cultural and socio-economic requirements of the nation (Tewari, 2025). The 2017 policy aimed to rationalize the curriculum and reform the entire system to ensure relevance in a globalized world, specifically targeting the reduction of gender gaps and the elimination of rural-urban imbalances (Singh, 2025).

A pivotal shift in the governance of education occurred with the 18th Constitutional Amendment, which devolved the social sector ministries to the provinces and inserted Article 25(a) into the Constitution, guaranteeing free and compulsory education for all children aged 5 to 16 (Yaseen et al., 2025). This devolution necessitated a collaborative framework, leading to the establishment of the Inter-Provincial Education Ministers Conference (IPEMC), a forum designed to ensure coordination and the setting of minimum national standards for quality education (MoFEPT, 2016). The National Education Policy Development Framework (NEPDF) 2024 represents the most recent iteration of this collaborative effort, providing guidelines for federal and provincial governments to align their policies with modern requirements, including digital literacy, artificial intelligence, and climate change adaptation (PIE, 2024).

2.1 The NICT Strategy and Digital Pakistan Vision

Parallel to general education policies, the National Information and Communication Technology (NICT) Strategy for Education was developed to specifically empower professionals and enhance quality across primary, secondary, and vocational sectors (Natarajan et al., 2021). This strategy is reinforced by the broader Digital Pakistan Vision 2019, which seeks to modernize the nation's

digital infrastructure and expand the knowledge-based economy (Law, 2022). The vision underscores that digital transformation is not merely a technological shift but a social and policy challenge that requires bridging access gaps and ensuring equitable participation in digital learning ecosystems (Jamil & Khan, 2024). Under the Uraan Pakistan initiative, the government has set ambitious targets, including achieving a 90 percent literacy rate and creating a "Quantum Valley" to position Pakistan as a global technology hub (Ministry of Planning, Development and Special Initiatives, 2024).

3. Empirical Analysis of Academic Achievement and Learning Outcomes

The impact of technology integration on academic performance in Pakistani secondary schools has been the subject of extensive empirical research. Comparative studies between traditional teaching methods and technology enhanced instructional approaches have consistently favored the latter, particularly in cognitively demanding subjects such as mathematics and science (Rind et al., 2022). A quantitative study involving 240 students across major urban centers Lahore, Karachi, and Islamabad revealed that experimental groups utilizing digital tools demonstrated significantly higher academic achievement after a 16-week intervention. These students showed improved conceptual understanding and a greater ability to move beyond the rote learning methods that have traditionally dominated the public sector (Mehmood & Ali, 2024). In Punjab, a study of 309 middle school science teachers across 45 public schools provided further evidence of technology's efficacy. The research established a strong positive correlation between access to technology, teacher digital competency, and student achievement in science (Asad et al., 2021). Digital tools such as interactive simulations, virtual labs, and visualizations allow students to interact with complex scientific concepts that are often difficult to grasp through static textbooks alone (Afzal et al., 2019). These tools have been shown to lower the "cognitive load" for students, allowing them to focus on scientific inquiry rather than the mechanics of learning, thereby leading to improved performance in assessments and higher test scores (Olugbade & Hohlfeld, 2024).

3.1 The National Achievement Test (NAT) 2023 Findings

The National Achievement Test 2023, conducted by the Pakistan Institute of Education (PIE), provides a nuanced comparison of learning outcomes in the Islamabad Capital Territory (ICT) (Shah, 2024). The data indicates that while private schools are often perceived as superior, the performance gap in public schools is narrower than commonly assumed, particularly in regions where government investment is high (PIE, 2024).

Table 1: Learning Outcomes Comparison by School Type in Islamabad Capital Territory (NAT 2023)

Subject Area	Public School Average (ICT)	Private School Average (ICT)	Statistical Significance
English	43%	44%	Private slightly higher; public scores skewed lower
Urdu	59%	58%	Public slightly higher performance
Mathematics	39%	38%	Public slightly higher performance
ICT Potential	Moderate-High	High	Both sectors show high student enthusiasm

These results suggest that public schools, when adequately resourced, can produce learning outcomes that rival or exceed those of low-to-middle fee private schools (Muzaffar et al., 2023).

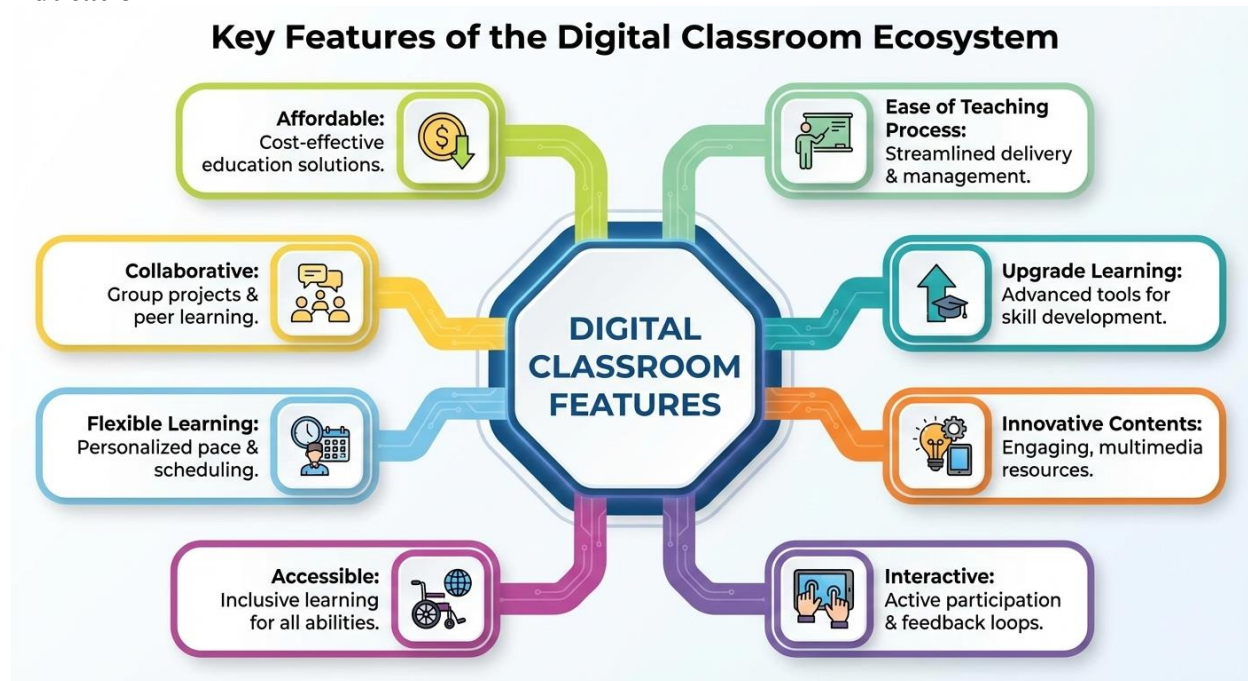
The slight edge held by public schools in Urdu and Mathematics can be attributed to the significantly higher professional and academic qualifications of public sector teachers, a majority of whom hold Master's degrees and have over 11 years of teaching experience (Ahmad et al., 2024).

4. Psychological and Behavioral Impacts: Engagement and Motivation

Digital classroom technologies have transformed the psychological landscape of the classroom, shifting the role of the student from a passive recipient to an active participant. Surveys indicate that an impressive 72 percent of teachers strongly agree that ICT tools boost student engagement (Haque, 2025). Technology-integrated classrooms foster a more dynamic learning environment characterized by increased curiosity and interest in the subject matter (Qureshi et al., 2023). This is particularly evident in science education, where digital tools provide personalized learning experiences that spark interest and encourage collaborative inquiry among students (Nazir et al., 2024).

Furthermore, digital platforms like the Learning Passport (LP) a UNICEF and Microsoft collaboration have demonstrated a high impact on student motivation. At the Government Girls Comprehensive High School in Karachi, students reported a heightened eagerness to attend LP classes, citing the interactive nature of the digital content, which includes instructional videos and games, as a primary motivator (Shahid et al., 2025). The LP program allows students to learn at their own pace, fostering a sense of autonomy and self-directed learning that is rarely seen in traditional settings. By breaking down complex learning objectives into comprehensible multimedia components, these technologies empower students to take ownership of their academic progress (UNICEF Pakistan, 2023).

Figure 1. The Multi-Dimensional Impact of the Digital Classroom Ecosystem on Pakistani Education



5. Infrastructure Deficiencies and the Digital Divide

Despite the potential of digital tools, their implementation in Pakistan is severely constrained by a profound digital divide that manifests along geographic, socio-economic, and gender lines (Khan

et al., 2024). The 2022 Network Readiness Index positions Pakistan at 90th among 134 nations, highlighting systemic inefficiencies in governance, technological adoption, and human capital development (Criterion Quarterly, 2023). A persistent urban-rural asymmetry exists, with 55 percent of urban residents having internet access compared to only 21 percent in rural areas. This disparity is even more pronounced in the education sector, where many rural schools lack even the minimum ICT amenities (Shams et al., 2025).

5.1 The Connectivity and Resource Crisis

The "last-mile connectivity" issue remains a significant hurdle for public schools. A staggering 60 percent of both teachers and students cite slow or non-existent internet as a major challenge to digital transformation (Khaliq, 2025). Furthermore, 50 percent of teachers report that Learning Management Systems (LMS) are completely unavailable in their institutions. In underdeveloped regions like Balochistan, the situation is even direr; a study in Loralai district found that not a single functional computer lab met national or international standards (Lawal & Sain, 2024). For many schools, ICT resources are often described as "showpieces" that remain unused due to unreliable power supplies and lack of internet access (Naeem et al., 2025).

Table 2: Regional Comparison of Digital Infrastructure Metrics

Infrastructure Metric	Pakistan	India	Bangladesh	Vietnam
Fiber Connectivity Score (0-100)	16	29	26	62
Individuals Using Internet (%)	21%	46%	N/A	N/A
Fixed Broadband Adoption (%)	1%	N/A	N/A	N/A
ICT Development Index Score	32.23	40.02	N/A	N/A

The data reveals that Pakistan underperforms relative to its regional counterparts in critical domains of digital infrastructure, which directly impacts the ability of public schools to integrate technology effectively (Criterion Quarterly, 2023). The high cost of personal digital devices is identified as the single most prominent barrier, with 75 percent of teachers and 82 percent of students considering affordability a major challenge (Mercader et al., 2020).

6. Provincial Implementations: Heterogeneous Progress

The impact of digital technologies in public schools varies significantly across Pakistan's provinces, reflecting different strategic priorities and levels of institutional readiness (Bhutto et al., 2025).

6.1 Punjab: Strategic Integration and Science-Based Models

Punjab has been a leader in the structured integration of technology into science education. Under the Public Sector Development Programme (PSDP), the province established 200 blended learning smart classrooms in the Islamabad Capital Territory (ICT), equipped with smart screens, digital devices, and LMS-driven content (Ramzan et al., 2025). Evidence from randomized control trials (RCTs) in Punjab suggests that providing technology to instructors, rather than directly to students, is a more cost-effective approach that yields better learning results (Beg & Ahmed, 2022). However, the eLearn Punjab project also faced challenges, as tablets provided directly to students sometimes reduced achievement by approximately 0.4 standard deviations due to their potential to distract students from core educational activities (Hassan, 2023). This emphasizes that technology's impact is contingent upon pedagogical alignment rather than mere device access (Mehmood & Ali, 2024).¹³

6.2 Sindh: Decentralization and Targeted Literacy Programs

In Sindh, the School Education and Literacy Department (SELD) has focused on decentralization and addressing the needs of marginalized children through public-private partnerships. The Sindh Technical Assistance for Development through Enhanced Education Programme (STA DEEP), supported by the EU and UNICEF, introduced a school clustering model that decentralized authority from the provincial to the district level for 400 pilot schools (Chang et al., 2024). This decentralization allowed for more responsive school management and the implementation of digital monitoring systems to track student enrollment and staff attendance (UNICEF, 2024).

The Accelerated Digital Learning Program (ADLP) in Sindh has pioneered the use of "Digital Micro-Schools" to bring quality education to out-of-school children. In its first phase, 100 micro-schools were established, using game-based learning to improve literacy and numeracy (Siyab et al., 2024). The success of this pilot is evidenced by the fact that 2,940 children have already transitioned to mainstream schools, with girls consistently outperforming boys in all subjects (Shah, 2025). Additionally, the Sindh Education Foundation (SEF) has integrated ICT into over 2,900 schools, providing tablets and LED TVs to enhance science teaching in rural districts like Khairpur (Tariq & Farooq, 2023).

6.3 Khyber Pakhtunkhwa: Human Capital and Merged Districts

Khyber Pakhtunkhwa (KP) has leveraged its "Digital KP" strategy to drive growth and improve service delivery in education (Khyber Pakhtunkhwa Information Technology Board, 2023). The province has placed a significant emphasis on training youth in the newly merged districts, providing 870 youth with employable digital skills (Ndou, 2023). The KP IT Board's flagship internship program has achieved a 100 percent employability rate for its 126 fellows, demonstrating the power of digital skills to overcome unemployment challenges (KPITB, 2023). Furthermore, KP launched the country's first online school, offering free classes for grades 6, 9, and 11, specifically designed to bridge the educational gap for thousands of students in remote and mountainous areas (Elementary & Secondary Education Foundation, 2024).

6.4 Balochistan: The Access and Quality Crisis

Balochistan faces the most daunting challenges in the country, with a literacy rate of only 46 percent and 1.3 million children attending school out of a population of 3.6. The Balochistan Education Sector Plan (2020-2025) provides a roadmap for addressing these issues, prioritizing foundational literacy and numeracy (Balochistan Education Department, 2021). While headteachers and students show a keen desire for technology integration, the province's progress is hindered by severe infrastructural shortcomings, including 850 schools without buildings and a general lack of electricity and potable water (Riaz et al., 2024). Despite these barriers, technology integration is viewed as an effective solution to overcome geographical barriers and reach students in the province's vast, remote areas (Rahim & Bibi, 2023).

7. Socio-Economic and Gender Realities in Digital Education

The impact of digital classroom technologies is deeply intertwined with Pakistan's socio-economic and gender disparities. The dropout rate for girls rises dramatically from 34 percent in primary school to 73 percent in secondary school, often due to the long distances between homes and schools in rural areas (World Bank, 2023). Digital technologies, such as distance learning and online micro-schools, offer a potential solution to this crisis by making education accessible within the local community (Shah, 2025).

However, a gender-related digital divide persists. Female mobile internet usage is significantly lower than that of males, and girls in conservative rural regions often face additional cultural

barriers to using digital tools (Majeed et al., 2024). Programs like the Learning Passport in Sindh specifically target these marginalized groups, with 90 percent of its users being girls. By narrowing the digital gender divide, these initiatives not only enhance learning outcomes but also empower young women with the skills necessary to participate in the global knowledge economy (UNICEF Pakistan, 2023).

7.1 Economic Barriers and the Affordability Gap

The financial burden of technology is a major deterrent for public school families. In rural areas, purchasing a computer or paying for internet access remains unaffordable for many (Pakistan Children Relief, 2024). This socioeconomic stratification ensures that students from affluent urban backgrounds continue to have a significant advantage over their peers in public and rural schools (Criterion Quarterly, 2023). This inequality contributes to a general "education divide," where public institutions lag behind private colleges and universities in terms of both infrastructure and trained personnel (Hussain & Alieto, 2024).

8. Teacher Digital Competency and Professional Development

The effectiveness of digital classroom technologies is ultimately determined by the competency of the educators who use them. The Technological Pedagogical Content Knowledge (TPACK) framework highlights that teachers must be able to integrate technology with pedagogy and content knowledge to create interactive learning environments (Falloon, 2020). In Pakistan, while most teachers possess basic digital skills like using email or MS Office, there are serious lags in advanced skills such as the use of Learning Management Systems (LMS) and the development of digital teaching aids (Mahmood & Bokhari, 2023).

A significant number of factors contribute to low confidence among teachers, including a lack of structured professional development courses and institutional support. Many educators feel insecure about using technology due to a lack of relevant training and technical support a phenomenon sometimes described as "technophobia" (Lawal & Sain, 2024). To address this, the Ministry of Education has partnered with Google to certify over 400 teachers in the ICT region, with plans to upgrade 50 schools to Google Education Plus (Fernández-Batanero et al., 2022). The Sindh government has also introduced Teacher Licensing initiatives to ensure that educators meet modern pedagogical standards (School Education & Literacy Department, 2023).

9. Institutional Governance and Digital Monitoring Systems

Digital technologies have revolutionized the governance and management of public education in Pakistan. Automation initiatives, including student profiling, GIS mapping, and centralized dashboards, are being used to enhance operational efficiency (Ministry of Planning, Development and Special Initiatives, 2024). The District Education Performance Index (DEPIx) serves as a critical evaluation framework, identifying high- and low-performing districts to support data-driven policy decisions and promote accountability (Geletu, 2024).

9.1 Biometrics and Digital Attendance

Digital attendance systems have become a popular and effective solution for tracking both student and teacher attendance, thereby improving discipline and transparency. These systems, utilizing QR codes, facial recognition, and GPS-based check-ins, have been shown to increase punctuality and reduce "proxy attendance" (Azizah & Patel, 2025).

Table 3: Impact of Digital Attendance on Educational and Operational Parameters

Parameter	Impact of Digital Attendance	Statistical Correlation
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Operational Efficiency	High; reduces manual errors and data loss	N/A
Student Performance	Significant positive relation with academic results	Correlation of 0.642 (Azizah & Patel, 2025)
Accountability	Enhances transparency for administrators	Chi-Square significant
Retention	Helps identify chronic absenteeism for early intervention	N/A

The implementation of these technologies in Sindh has allowed the SELD to monitor over 40,000 schools, enhancing the management of educational resources and supporting efforts to improve outcomes for students. However, user resistance and technical issues remain challenges to the universal adoption of digital attendance (Soomro et al., 2025).

10. Public-Private Ecosystems and Global Partnerships

The digital transformation of Pakistan's public schools is heavily reliant on collaboration with international organizations and the private sector. Partnerships with Microsoft, Google for Education, and UNICEF have provided the hardware, software, and digital content necessary to launch pilot programs across the country (Suhail et al., 2025). The Sindh Education Foundation (SEF) has successfully partnered with NGOs and private sector organizations to deliver quality education to underprivileged communities, leveraging local expertise and resources (Tariq & Farooq, 2023). These collaborative efforts are essential for mobilizing the funding and technical support required to sustain large-scale technological interventions (Mehmood et al., 2025).

11. Future Roadmap: Uraan Pakistan and Beyond

The government's roadmap for education reform, under the Uraan Pakistan initiative (2024-2029), envisions a fully modernized and digitally empowered education system (Ndou, 2023). The strategy focuses on transitioning to a knowledge economy through the promotion of efficient ICT initiatives and the development of industrial-academic resources (Criterion Quarterly, 2023). Key future objectives include:

1. **Curriculum Modernization:** Revising the national curriculum to incorporate Coding, Artificial Intelligence, Financial Literacy, and Climate Change as core subjects for the 21st century (Shah, 2024).
2. **Infrastructure Expansion:** Setting up 50 new IT labs in rural boys' schools in ICT and upgrading schools in underserved districts across all provinces (Natarajan et al., 2021).
3. **Out-of-School Children (OOSC) Fund:** Establishing a national fund to incentivize and support interventions aimed at decreasing the number of OOSC through digital and alternative learning pathways (Siyab et al., 2024).

Quantum Valley and AI Adoption: Positioning Pakistan as a global technology hub through the creation of national centers for nanotechnology, quantum computing, and AI (Ahmad et al., 2024).

12. Conclusions

The integration of digital classroom technologies in Pakistan's public secondary schools offers a credible pathway to reverse decades of educational stagnation, elevate learning outcomes, increase student engagement and motivation, reduce dropout rates (especially among girls), and modernize pedagogical practices. Evidence from randomized trials, national assessments, and provincial pilots consistently shows that thoughtfully deployed digital tools when aligned with sound pedagogy, supported by competent teachers, and embedded within structured programs produce

meaningful gains in conceptual mastery, science and mathematics performance, and self-directed learning, while diminishing dependence on rote memorization. Provincial heterogeneity underscores both the feasibility of large-scale impact (Punjab's smart classrooms, Sindh's digital micro-schools, KP's online schooling) and the critical importance of context-specific strategies. However, systemic constraints unreliable power and internet, prohibitive device costs, profound rural-urban and gender digital divides, inadequate teacher training, and uneven institutional readiness continue to limit equitable benefits and threaten to widen existing inequalities if left unaddressed. Achieving the ambitious goals of Uraan Pakistan, the NEPDF 2024, and SDG-4 therefore requires a decisive shift from pilot-based and fragmented interventions toward sustained, coordinated national action. Priority must be given to: (1) closing last-mile connectivity and electricity gaps, (2) dramatically expanding affordable, high-quality teacher professional development in digital pedagogy, (3) prioritizing device and connectivity provision to teachers over indiscriminate student distribution, (4) scaling proven models (Learning Passport, digital micro-schools, blended smart classrooms) with strong equity safeguards for girls and rural students, and (5) institutionalizing data-driven monitoring and accountability through digital governance tools. Only through such holistic, inclusive, and adequately resourced reforms can Pakistan convert the promise of digital education from an aspirational vision into a broad-based driver of learning recovery, human capital development, gender equality, and long-term socio-economic progress.

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