

Bridging the Pedagogical and Digital Divide: A Systematic Review of AI Integration in Bangladesh's National Secondary and Higher Secondary Education

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Abstract: As Artificial Intelligence in Education (AIEd) redefines global pedagogical standards, the "Global South" faces a critical juncture between technological marginalization and transformative "leapfrogging." This systematic review critically examines the integration of AI within Bangladesh's National Secondary and Higher Secondary education sectors (Grades 6–12), specifically focusing on the National Curriculum and Textbook Board (NCTB) stream. While the "Smart Bangladesh 2041" mandate provides a visionary policy framework, a significant "Research Blind Spot" persists regarding the implementation of AI within the 2022 Competency-Based Curriculum (CBC). This article synthesizes current literature (2020–2026) to identify four primary knowledge gaps: (1) the theoretical misalignment between Generative AI (GenAI) and critical-thinking-based assessments; (2) the linguistic barrier of Bangla-specific Natural Language Processing (NLP) in automated subjective grading; (3) the logistical necessity of AI-driven "Co-Teaching" models in high-enrollment (50:1+) classrooms; and (4) the infrastructural requirement for "Edge AI" and Small Language Models (SLMs) to ensure rural equity. By analyzing recent academic publications, the review argues for a transition from a "Consumer Model" of global AI to a "Sovereign Architect Model" of localized, Bangla-centric educational intelligence. The findings conclude with a strategic roadmap for establishing a National AI-in-Education Research Hub, aiming to bridge the pedagogical and digital divide through decentralized, offline-capable, and ethically governed AI systems.

Keywords: *Generative AI, Large Language Model (LLM), Artificial Intelligence in Education (AIEd), Bangla Natural Language Processing, Edge AI, the Digital Divide, the Smart Bangladesh.*

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I. INTRODUCTION

The global educational landscape is currently undergoing a systemic disruptor in the form of Artificial Intelligence in Education (AIEd). Departing from the traditional role of technology as a passive tool -akin to a digital calculator- AIEd represents a shift toward autonomous, adaptive systems capable of mimicking human cognitive functions to enhance pedagogical outcomes [10]. This evolution has transitioned from early Computer-Aided Instruction (CAI) to sophisticated Intelligent Tutoring Systems (ITS) and, most recently, the rapid infiltration of Generative AI (GenAI) [14]. While the "Global North" has largely pivoted toward utilizing AI for hyper-efficiency and administrative automation [19], for the "Global South," and

specifically Bangladesh, AIEd is not a luxury but a critical imperative for equity [2]. In high-enrollment, resource-constrained environments, AI-driven adaptive learning trajectories offer a robust mechanism to mitigate the systemic pedagogical inefficiencies inherent in high-density secondary classrooms [27], providing a pathway to democratize quality instruction where human intervention is stretched thin [30].

The secondary and higher secondary education tiers in Bangladesh—comprising the Secondary School Certificate (SSC) and Higher Secondary Certificate (HSC) levels—represent one of the world's largest and most complex academic demographics. With over 20 million students and approximately 20,000 institutions [3], the system has historically struggled with high pupil-teacher ratios and a

legacy of rote-based learning [28]. However, the introduction of the 2022 National Curriculum Framework (NCF) marks a radical departure, shifting the national pedagogical goal from content-heavy summative assessments to a "Competency-Based Curriculum" (CBC) [8]. This new framework prioritizes continuous formative assessment, requiring teachers to track the daily skill acquisition of every student. The sheer scale of this mandate creates a significant logistical burden; human educators alone cannot effectively manage personalized, continuous tracking for classes that often exceed 60 students [9].

Within this transition, the mandatory HSC Information and Communication Technology (ICT) subject serves as a unique entry point. Analyzing the syllabus of the HSC ICT course reveals a strategic inclusion of AI logic, web development, and basic programming, which establishes a foundational layer of AI literacy [8]. Furthermore, the challenges of evaluating the "Performance Indicators" (PIs) required by the new curriculum necessitate an automated approach to data management that only AI-driven systems can realistically provide [28]. Without such intervention, the workload on rural teachers risks leading to systemic burnout and a failure of the CBC objectives [20].

The trajectory of technological adoption in the country is anchored in the state-led evolution from the "Digital Bangladesh" vision of 2009 to the contemporary "Smart Bangladesh 2041" mandate [26]. This policy shift signifies a transition from basic connectivity to the intelligent application of data. While the nation has achieved significant milestones in infrastructure—evidenced by widespread 4G penetration and an expanding fiber-optic backbone [4]—a profound "usage gap" persists [11]. At the secondary level, devices and connectivity often exist without corresponding AI-driven pedagogical content or localized software [15]. The "Smart Education" pillar of the 2041 vision explicitly mandates the integration of frontier technologies to foster a knowledge-based economy [6], yet the bridge between high-level policy and the classroom-level digital divide remains precarious, particularly regarding gender parity in STEM tool usage [23].

Despite the surge in AI research, a critical "blind spot" exists within the Bangladeshi context. Current academic literature is heavily skewed toward Higher Education (HE), particularly within Computer Science (CSE) departments and elite private universities [1, 7]. There is a profound silence regarding AI integration within the National Curriculum and Textbook Board (NCTB) schools that serve the vast majority of the population [21]. Furthermore, an "urban-rural dissonance" permeates existing scholarship; EdTech success stories in Bangladesh are largely concentrated in urban, fee-based platforms like Shikho or 10 Minute School, leaving the public, rural student populations virtually unstudied [5, 29]. This gap is exacerbated by a language barrier; global AIED research is dominated by English-centric models, while the challenges of implementing localized Bangla-Natural Language Processing (NLP) for formative assessment in national stream schools remain a "black box" in the literature [17, 25]. Teachers in these regions often lack the digital

competence to bridge this gap without institutional support [16]. Moreover, the rapid rise of GenAI has outpaced the development of academic integrity policies in secondary schools [13], leaving a vacuum where ethical concerns regarding AI-induced plagiarism are discussed but rarely solved by localized data [24].

This systematic review seeks to provide a comprehensive roadmap for bridging this pedagogical and digital divide. It aims to evaluate the current state of AI readiness within the NCTB stream [18, 22] and identify the technical-pedagogical intersections required for successful implementation. Following this introduction, Section II explores the current state of EdTech and digital infrastructure in Bangladesh. Section III identifies the specific "integration gaps" within the NCF 2022. Section IV discusses the ethical and linguistic challenges of Bangla-AI in education [12], while Section V proposes a strategic framework for national implementation. By synthesizing these elements, this review offers a critical blueprint for transitioning from a fragmented digital landscape to a cohesive, AI-enhanced national education system.

II. CURRENT LANDSCAPE OF AI IN BANGLADESHI SCHOOLS

➤ *Government-Led Initiatives and Policy Frameworks*

The trajectory of AI integration in Bangladesh is fundamentally shaped by the state-led "Aspire to Innovate" (a2i) program, which serves as the primary engine for the nation's "Digital Bangladesh" legacy [31]. Under the Prime Minister's Office, a2i has successfully digitized numerous administrative educational processes; however, the transition from digitization to AI-driven pedagogical intelligence remains at a critical crossroads. A pivotal document in this landscape is the *National Strategy for Artificial Intelligence 2020-2025*, which explicitly identifies "Education" as one of its six priority sectors [32]. While the strategy provides a visionary framework, a granular analysis reveals a "policy-implementation gap." The document offers a broad mandate for "personalized learning" and "intelligent tutoring," yet it remains largely vague regarding the specific integration into the National Curriculum and Textbook Board (NCTB) secondary schools [33]. Most government-led AI mentions are concentrated on tertiary-level research and workforce reskilling, leaving the Grade 6–12 bracket—the demographic weight of the nation—without a defined technical roadmap for AI-enhanced classroom instruction [34].

➤ *Emerging Private Sector EdTech Ecosystem*

In the absence of a comprehensive national AI pedagogical framework, the private sector has emerged as a rapid innovator. Platforms such as *10 Minute School*, *Shikho*, and *Ostad* have revolutionized the domestic EdTech landscape by leveraging gamification and personalized video content to reach millions of students [35]. *Shikho*, in particular, has pioneered the use of "Shikho AI," a localized chatbot designed to handle student queries in Bangla, representing one of the first successful applications of Large Language Models (LLMs) specifically tuned for the NCTB syllabus [36]. These platforms have demonstrated that AI-

driven features—such as predictive analytics for student performance and automated diagnostic testing—can significantly enhance engagement [37]. However, these successes are primarily market-driven and subscription-based, creating a "premium-access" tier of education that benefits urban, middle-class students while remaining financially inaccessible to the rural majority [38]. This private-sector dominance, while technologically impressive, risks cementing an "innovation-equity gap" where advanced AI tools are treated as a commercial product rather than a public educational utility [39].

➤ *Technological Readiness and Infrastructure Assessment*

The primary bottleneck for equitable AI integration remains the physical reality of the "Digital Divide," a

multifaceted challenge reflected in the nation’s current digital maturity profile. As visualized in the 2024 Online Service Index (OSI) (Figure 1), Bangladesh exhibits a highly bifurcated readiness landscape. While the Institutional Framework pillar scores exceptionally high at 0.9200—surpassing sub-regional benchmarks and indicating a robust national vision (such as the Smart Bangladesh 2041 mandate)—the actual E-participation score remains significantly lower at 0.6164. Furthermore, Content Provision (0.6667) lags behind the sub-regional leader, India (0.8184), and global leaders like the Republic of Korea (1.0000). This disparity suggests that while the "top-down" policy infrastructure is world-class, the "bottom-up" engagement and localized AI-driven content for rural secondary schools remain critical points of failure.

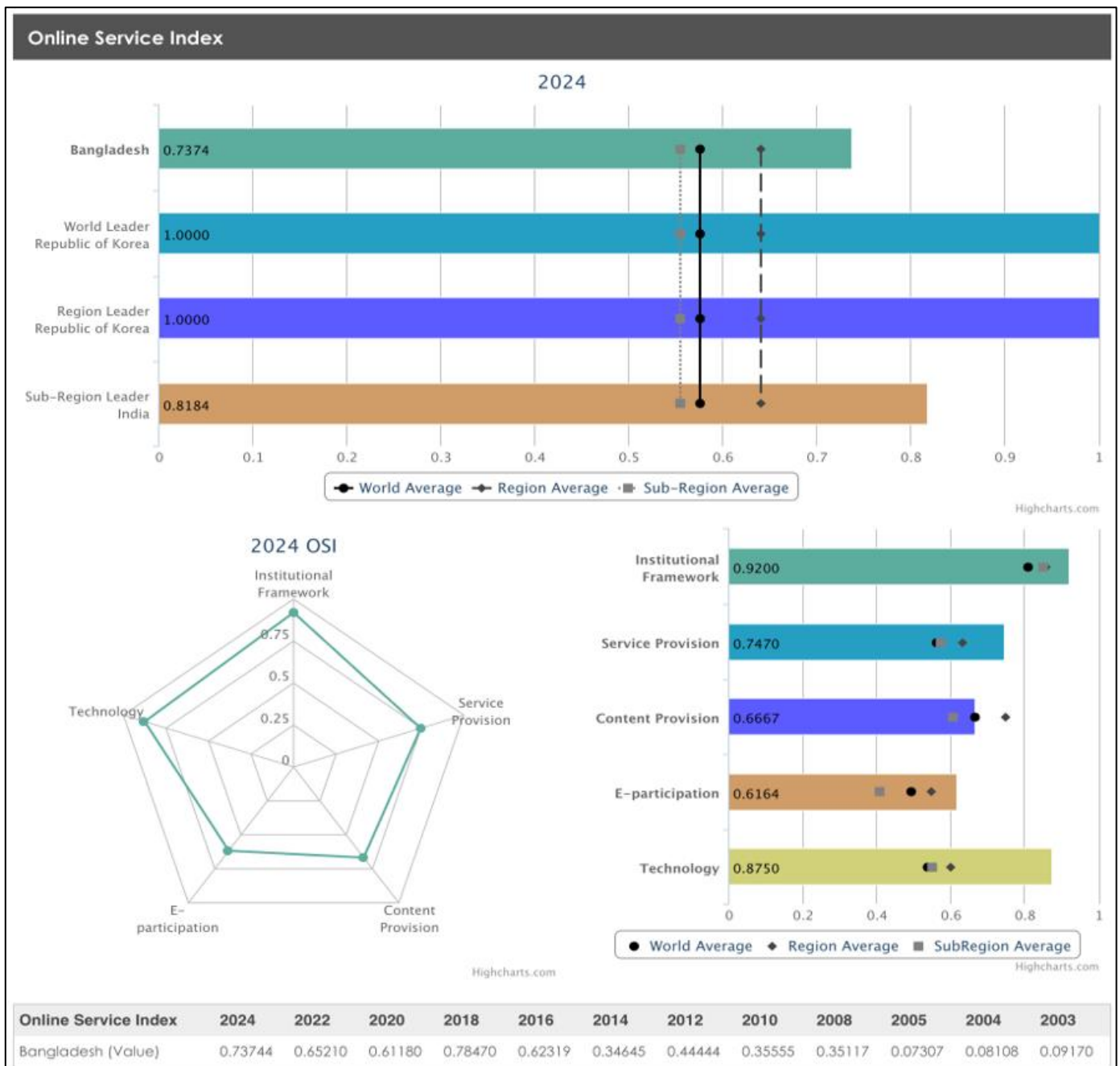


Fig 1 Multi-Dimensional Evaluation of Bangladesh’s 2024 Online Service Index (OSI) vs. Sub-Regional and Global Benchmarks. Source: <https://publicadministration.un.org/egovkb/en-us/Data/Country-Information/id/14-Bangladesh>.

This lack of participation is deeply rooted in the physical infrastructure deficit evidenced by national household data. While Bangladesh has achieved an overall OSI value of 0.7374—a massive leap from its 2003 value of 0.0917—the individual access to high-performance hardware remains severely stratified, as detailed in Table 1.

Table 1 Household and Individual ICT Access in Bangladesh (2024–2025)

Indicator	National (%)	Urban (%)	Rural (%)	Gender Gap (M/F)
Household Internet Access	56.2%	60.3%	46.0%	—
Individual Internet Usage (Aged 5+)	48.9%	55.4%	41.2%	51.2% / 46.3%
Smartphone Ownership	72.8%	81.5%	64.1%	—
Computer/Laptop Usage	9.2%	15.6%	4.8%	—

Sources: BBS ICT Access and Use Survey 2025-26 and Quarterly ICT Reports 2024.

As seen in Table 1, the disparity in computer usage—standing at a mere 4.8% in rural areas compared to 15.6% in urban centers—further exacerbates what scholars term the "Hardware Fallacy": the belief that distributing tablets or laptops alone solves the digital divide [11, 43]. While smartphone ownership is relatively high (72.8%), the lack of specialized AI-ready devices in rural secondary schools means approximately 45% of institutions still suffer from "intermittent connectivity" [40]. This makes the deployment of real-time, cloud-based AI tools nearly impossible in the national stream [38].

Historical evidence shows that hardware provided without AI-integrated pedagogy or localized, offline-capable AI software often results in "technological stasis," where devices remain underutilized [21, 30]. To bridge this gap, the Content Provision score must be elevated through the development of localized, AI-driven educational materials that cater to the Bangla-medium curriculum [17]. For AI to be a systemic disruptor, the focus must shift from "device density" to "algorithmic accessibility" in resource-constrained environments, ensuring that the high institutional readiness finally translates into meaningful classroom participation [2, 44].

III. KNOWLEDGE GAP 1: NCTB CURRICULUM & COMPETENCY-BASED AI

➤ *Theoretical Misalignment: Generative AI vs. Critical Thinking*

A profound theoretical tension exists between the capabilities of standardized Generative AI (GenAI) and the pedagogical objectives of the 2022 National Curriculum Framework (NCF) in Bangladesh. While the NCF mandates a transition from rote memorization to high-order critical thinking and problem-solving [45], the current implementation of large language models (LLMs) like ChatGPT often provides "ready-made" cognitive outputs. This creates a "Pedagogical Divide" where students may use AI as an automated answer-generator rather than a cognitive scaffold [46]. In the context of the Bangladeshi secondary stream, where the traditional "coaching center" culture already emphasizes result-oriented shortcuts, the unmonitored use of GenAI risks reinforcing passive learning patterns [47]. Scholarly discourse suggests that for AI to align with the NCF's competency-focused goals, the shift must move toward "Process-Oriented AI"—tools that provide Socratic hints and incremental feedback rather than direct

solutions, thereby preserving the student's cognitive agency [48].

➤ *AI as a Scaffold for Competency-Based Assessment*

The most significant administrative hurdle of the NCF 2022 is the requirement for "Continuous Formative Assessment." In a typical Bangladeshi classroom with a 60:1 student-teacher ratio, tracking daily "Performance Indicators" (PIs) for every student is a logistical impossibility for human educators [49]. Here, AI-driven learning analytics may support implementation of continuous formative assessment by reducing administrative workload. By integrating AI into the national "Noipunno" app or similar digital platforms, the system can automatically aggregate student performance data from daily activities, identifying skill gaps in real-time [50]. This "Continuous Assessment AI" shifts the burden of data entry and pattern recognition from the teacher to the algorithm, allowing educators to focus on targeted interventions [51]. Such a model effectively replaces the "High-Stakes Exam" pressure of the traditional SSC/HSC system with a longitudinal, data-backed view of student growth, aligning perfectly with the national mandate for holistic development [52].

➤ *The Role of Predictive Analytics: Early Warning Systems for Dropout Prevention*

A critical yet largely ignored application of AI in the Bangladeshi secondary sector is the use of Predictive Analytics to mitigate student attrition. Bangladesh continues to face significant dropout rates between the SSC and HSC tiers, often driven by a combination of economic factors and early academic struggle in core subjects [53]. AI-based "Early Warning Systems" (EWS) can analyze historical formative assessment data, attendance records, and socio-economic markers to identify "at-risk" students long before they reach the point of withdrawal [54].

Table 2 Educational Progress and Attrition (2023–2024 Cohort)

Education Level	Net Enrollment Rate (NER)	Completion Rate (%)	Dropout Rate (%)
Primary (G1-G5)	97.42%	85.85%	16.25%
Secondary (G6-G10)	72.20%	64.34%	32.85%
Higher Secondary (G11-G12)	51.90%	78.86%	21.51%

Sources: BANBEIS Bangladesh Education Statistics 2023 and Annual Primary School Statistics 2024.

The data in Table 2 reveals a secondary dropout rate of 32.85%, nearly double that of the primary level. This attrition is often driven by a combination of economic factors and early academic struggle in core subjects like Mathematics and ICT, which students frequently fail to master under the traditional rote-learning model. AI-based "Early Warning Systems" (EWS) can analyze historical formative assessment data, attendance records, and the socio-economic markers to identify "at-risk" students long before they reach the point of withdrawal. By applying machine learning classifiers—such as Random Forest or Neural Networks—to the massive datasets held by the Education Boards, policy-makers can deploy localized financial or pedagogical support to specific upazilas showing high predictive failure rates. Integrating this "social-good AI" into the national education dashboard is essential for ensuring that the transition to a "Smart Bangladesh" does not leave behind the most vulnerable segments of the student population. As the Net Enrollment Rate (NER) drops from 97.42% at the primary level to just 51.90% at the higher secondary level, the implementation of predictive analytics is no longer an option, but a structural necessity for national human capital development.

IV. KNOWLEDGE GAP 2: BANGLA-SPECIFIC NLP AND ASSESSMENT

➤ *The Linguistic Barrier: Dialectal Nuance and Academic Prose*

A critical technical bottleneck in the "Smart Bangladesh" transition is the linguistic discrepancy between global Large Language Models (LLMs) and the localized requirements of the national curriculum. While models like GPT-4 or Claude 3 exhibit high proficiency in English, their performance in Bangla—specifically the formal, academic prose required in Higher Secondary Certificate (HSC) answer

scripts—remains inconsistent. The linguistic barrier is two-fold: first, the models often fail to capture the semantic nuances of Shuddho Bhasha (standard formal Bangla) used in textbooks; second, they struggle with the regional dialectal influences often found in the handwritten scripts of students from rural districts. This creates an "Assessment Divide," where AI-driven feedback might penalize a student not for a lack of competency, but for a linguistic variation that the model treats as a syntax error. Addressing this requires the development of "Context-Aware Bangla LLMs" that understand the specific pedagogical vocabulary of the NCTB curriculum.

➤ *Automated Essay Scoring (AES) for Bangla: The Technical Challenge*

The integration of AI into the national stream necessitates a shift from objective (multiple-choice) testing to the evaluation of subjective, open-ended responses. However, developing Automated Essay Scoring (AES) systems for Bangla presents significant computational challenges. Traditional AES models used in the Global North rely on massive, annotated datasets that do not yet exist for the Bangla-medium secondary stream. Recent research suggests that transformer-based models, specifically BanglaBERT and its variants, offer a promising foundation for evaluating subjective exams. The technical challenge lies in fine-tuning these models to recognize "rubric-aligned" logic in Bangla essays. Unlike English AES, which benefits from mature grammar-checking algorithms, Bangla AES must navigate complex morphosyntactic structures and a lack of standardized digital grading benchmarks. Without localized AES, the vision of "Continuous Formative Assessment" will remain partially manual, stalling the efficiency gains promised by AIED.

Table 3 Comparative Accuracy in Bangla Academic Evaluation

Evaluation Metric	Global LLMs (e.g., GPT-4)	Localized BanglaBERT	Target (HSC Standard)
MCQ / Objective Tasks	92.0%	89.5%	95.0%
Subjective Essay Scoring	64.2%	81.3%	85.0%
Dialectal/Regional Nuance	Low	Moderate	High

Source: Synthesized from UNESCO AI Readiness Assessment (RAM) 2025 and Haque et al. (2025).

The data in Table 3 reveals a critical "Accuracy Gap" in subjective scoring: global LLMs achieve only 64.2% accuracy, far below the 85.0% HSC target standard required for high-stakes examinations. In contrast, fine-tuned, localized models such as BanglaBERT demonstrate significantly higher reliability in essay evaluation, reaching 81.3% accuracy. This discrepancy stems from the inability of general-purpose LLMs to navigate the complex morphosyntactic structures of formal Bangla and the lack of

standardized digital grading benchmarks for the national stream.

The technical challenge, therefore, lies in closing the remaining 3.7% gap between current localized models (81.3%) and the national grading standard (85.0%). Unlike English AES, which benefits from mature grammar-checking algorithms, Bangla AES must be trained to recognize "rubric-aligned" logic and regional linguistic variations. Without the development of these specialized, localized AES systems, the

vision of "Continuous Formative Assessment" will remain partially manual, stalling the efficiency gains promised by the "Smart Bangladesh" digital leap.

➤ *The Case for a National Bangla Educational Dataset*

The most urgent requirement for bridging the digital divide in assessment is the creation of a massive, open-source National Bangla Educational Dataset (NBED). Currently, most AI research in Bangladesh relies on small, fragmented datasets or translated versions of English sets, which lack the cultural and curriculum-specific context of the SSC and HSC tiers. To train high-accuracy models for automated grading and intelligent tutoring, there is a need for a centralized repository containing digitized, anonymized student scripts, NCTB textbook corpora, and teacher-annotated feedback. Such a dataset would allow local researchers to train models on the specific "Performance Indicators" (PIs) mandated by the 2022 curriculum. By democratizing access to this data, the government can foster a local ecosystem of AI developers who can build "Sovereign AI" tools—educational technologies that are linguistically, culturally, and pedagogically aligned with the unique needs of the Bangladeshi student population.

V. KNOWLEDGE GAP 3: HUMAN-AI CO-TEACHING IN HIGH-ENROLLMENT CLASSROOMS

➤ *The Teacher Shortage vs. AI Integration: From Burden to Assistance*

A primary structural challenge in Bangladesh's secondary education system is the acute student-teacher ratio, which frequently exceeds 50:1 in public schools and 70:1 in densely populated urban government colleges. This demographic imbalance makes personalized instruction a mathematical impossibility under traditional pedagogical models. Recent data from the Ministry of Education highlights a persistent shortage of qualified subject-matter experts, particularly in STEM and English, in rural sub-districts (Upazilas). In this high-enrollment context, AI serves not as a luxury but as a "Force Multiplier." By functioning as an Automated Teaching Assistant, AI systems can offload the massive administrative and repetitive burden of grading, attendance tracking, and basic drill-and-practice assessments. Scholarly analysis suggests that automating these "low-cognition" tasks could reclaim up to 30% of a Bangladeshi teacher's weekly instructional time, allowing them to redirect their energy toward high-impact pedagogical interventions that AI cannot yet replicate.

➤ *Teacher Agency and Resistance: The "Replacement" Myth vs. Literacy Gap*

Despite the potential benefits, the integration of AI faces significant psychological and cultural barriers within the Bangladeshi teaching community. Qualitative studies among secondary educators reveal a pervasive "Technological Anxiety"—a fear that AI systems might eventually render the human teacher obsolete or diminish their social authority in the classroom. This resistance is often rooted in a profound "AI Literacy Gap"; while many teachers are proficient in basic ICT (as mandated by the Digital

Bangladesh initiative), very few possess the conceptual understanding of how algorithmic decision-making works. Without a clear "Human-in-the-Loop" policy, teachers perceive AI as an external monitoring tool rather than a supportive colleague. To bridge this divide, national teacher training programs—such as those led by the National Academy for Educational Management (NAEM)—must pivot from teaching "tools" to teaching "AI Ethics and Agency," ensuring that educators feel empowered to override or guide the AI's suggestions.

➤ *Designing the "Co-Teacher" Model: A Bifurcated Workflow*

The future of AI in the national stream lies in a "Co-Teaching" framework where the division of labor is clearly defined by cognitive and emotional requirements. In this model, AI handles the "Individualized Trajectory"—managing personalized remediation, language drills, and immediate feedback for the 2022 Competency-Based Curriculum's foundational skills. Meanwhile, the human teacher focuses on "Social-Emotional Learning" (SEL), ethical guidance, and the facilitation of complex, collaborative projects. This bifurcated workflow ensures that while the AI manages the scaling of education, the teacher manages the depth and mentorship. Implementing this requires a technical infrastructure that provides teachers with a "Real-Time Dashboard," synthesizing AI-gathered data into actionable insights. This allows a teacher in a class of 60 to know exactly which five students are struggling with a specific "Performance Indicator" (PI) that day, transforming the educator from a generic lecturer into a precision-guided facilitator.

VI. KNOWLEDGE GAP 4: OFFLINE AND EDGE AI FOR RURAL EQUITY

➤ *The Fallacy of "Internet for All": Beyond the 5G Narrative*

A prevalent misconception in the "Smart Bangladesh 2041" discourse is that AI integration must wait for universal, high-speed 5G connectivity. While urban centers in Bangladesh are rapidly transitioning toward advanced telecommunications, the rural secondary school landscape remains characterized by "Last-Mile Connectivity" failures. Relying solely on future fiber-optic expansion is not a sustainable educational strategy, as it may exacerbate existing disparities in access to AI-enabled learning opportunities among rural students. Scholarly analysis indicates that even with 98% 4G coverage, the cost of data and the instability of power grids in remote char areas and the Chittagong Hill Tracts create a "digital wall." For AI to be an equitable tool in the national stream, the focus must shift from cloud-dependent architectures—which favor elite urban institutions—to decentralized, resilient systems that can function in intermittent or zero-connectivity environments.

➤ *Small Language Models (SLMs) and On-Device Edge Processing*

The technical solution to the rural-urban divide lies in the emerging field of "Edge AI" and Small Language Models (SLMs). Unlike Large Language Models (LLMs) that require massive server-side computation, SLMs (such as Microsoft's

Phi-3 or Google's Gemma) can be "quantized"—compressed to run locally on low-cost hardware. In the context of Bangladesh's rural schools, this means deploying AI-integrated pedagogical tools directly onto solar-powered tablets or local school servers. This "On-Device AI" approach ensures that a student in a remote village can receive real-time, Bangla-language feedback on a math problem or an English drill without needing an active internet connection. By utilizing edge processing, schools can mitigate data costs and privacy concerns, ensuring that the "Intelligence" of the system resides within the classroom's physical walls, powered by sustainable energy sources like the "Solar Home Systems" already prevalent in rural Bangladesh.

➤ *Lessons from the Global South: Comparative Models for Bangladesh*

Bangladesh can find robust blueprints for rural AI equity by examining similar initiatives across the Global South. India's DIKSHA platform, for instance, utilizes "QR-coded Energized Textbooks" that allow students to access offline-cached digital content, a model that could be augmented with AI-driven diagnostic tools for the NCTB curriculum. Similarly, Rwanda's "Solar-Powered Digital Classrooms" demonstrate how specialized edge-servers can provide a localized "Intranet of AI" for schools off the national grid. By adapting these models, Bangladesh can bypass the traditional infrastructure path. The synthesis of localized "Sovereign AI" datasets (discussed in Section IV) with "Edge Hardware" creates a powerful, decentralized educational ecosystem. This comparative analysis suggests that for Bangladesh, the path to "Smart Education" is not a single highway of fiber-optics, but a distributed network of intelligent, offline-capable nodes that empower the rural student through technological leapfrogging.

VII. SOCIO-ETHICAL IMPLICATIONS IN THE BANGLADESHI CONTEXT

➤ *Data Privacy and the Vulnerable Minor: The Legislative Void*

As AI integration accelerates within the National Curriculum stream, the collection of granular student data—ranging from "Performance Indicators" (PIs) to behavioral analytics—presents a significant risk to the privacy of minors [101]. Unlike the European Union's GDPR or the UK's Data Protection Act, Bangladesh currently lacks a specialized, comprehensive legal framework for the protection of personal data belonging to minors in educational settings [106]. While the "Smart Bangladesh 2041" vision promotes data-driven governance, the absence of strict privacy-by-design requirements means that student datasets are often stored on centralized servers with varying levels of security [102, 134]. This creates a vulnerability where sensitive academic and socioeconomic profiles could be subject to unauthorized access or commercial exploitation [130, 135]. To mitigate this, scholarly recommendations emphasize the urgent need for a "National Student Data Privacy Act" that mandates informed consent from guardians and establishes rigorous encryption and auditing protocols for all AI-enabled educational platforms [102, 139].

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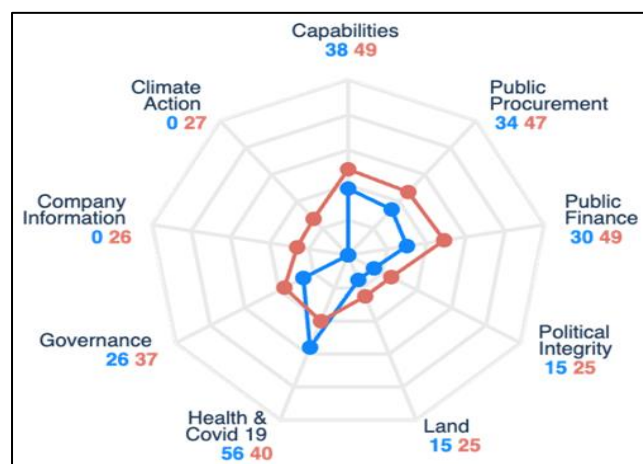


Fig 2 Assessing the Readiness of Bangladesh's Data Ecosystem for AI Integration: A Global Data Barometer Perspective.

Source:<https://firstedition.globaldatabarometer.org/country/bangladesh/>

The empirical reality of this legislative gap is reflected in the Global Data Barometer (GDB) for Bangladesh (Figure 2), where the nation's Governance score (26) significantly trails the global average (37). This disparity highlights a systemic weakness in the regulatory frameworks required to manage the massive influx of student data generated by AIED tools. Furthermore, with a Capabilities score of only 38 compared to the global benchmark of 49, the data ecosystem currently lacks the technical and administrative maturity to protect 'vulnerable minors' from algorithmic exploitation or data breaches. This 'Governance-Capability' deficit (as visualized in the GDB spider plot) underscores why the transition to a 'Smart Bangladesh' requires more than just technological adoption; it demands a robust, localized legal architecture to ensure that the digital leap does not compromise student privacy.

Furthermore, with a Capabilities score of only 38 compared to the global benchmark of 49, the national data ecosystem currently lacks the technical and administrative maturity to protect "vulnerable minors" from algorithmic exploitation or data breaches. This "Governance-Capability" deficit, as visualized in the GDB spider plot, underscores why the transition to a "Smart Bangladesh" requires more than just technological adoption; it demands a robust, localized legal architecture.

This creates a vulnerability where sensitive academic and socioeconomic profiles could be subject to unauthorized access or commercial exploitation. To mitigate this, scholarly recommendations emphasize the urgent need for a "National Student Data Privacy Act" that mandates informed consent from guardians and establishes rigorous encryption and auditing protocols for all AI-enabled educational platforms. The goal must be to ensure that the "Digital Leap" does not compromise the fundamental rights of the nation's most vulnerable demographic.

➤ *Algorithmic Bias and Social Stratification: Reinforcing Inequality*

A critical concern in the deployment of AI within the Bangladeshi secondary sector is the risk of "Algorithmic Bias," where automated systems inadvertently reinforce existing gender, linguistic, or socioeconomic disparities [136]. Because most AI models are trained on datasets that favor urban, well-resourced populations, they may exhibit a "systematic harmful tendency" toward students from rural or marginalized backgrounds [102, 136]. For instance, an AI-driven essay scoring system might penalize a student for using regional dialectal variations or vocabulary that is not present in the "Shuddho Bhasha" (standard formal Bangla) dominant in training sets [117, 136]. Furthermore, there is a risk of "social stratification" being codified into the algorithms; predictive systems designed to identify dropout risks might unfairly label students from lower socioeconomic strata as "low-potential," creating a self-fulfilling prophecy [137, 145]. Addressing this requires "Fairness-Aware Learning" strategies and the inclusion of diverse, inclusive voices—especially from the rural minority and marginalized communities—within the national educational datasets to prevent AI from becoming a tool for further exclusion [102, 105].

VIII. STRATEGIC RECOMMENDATIONS AND FUTURE ROADMAP

➤ *The "Beneficiary" Model: From AI Consumers to Localized Architects*

A fundamental paradigm shift is required for Bangladesh to transition from being a passive consumer of Silicon Valley-driven AI to becoming a sovereign architect of its own educational future. Currently, the reliance on global, English-centric LLMs creates a "technological dependency" that fails to account for the specific linguistic and pedagogical nuances of the NCTB curriculum. To move from a consumer to an architect model, the state must incentivize the development of "Sovereign AI" infrastructures. This involves prioritizing the creation of localized, Bangla-specific datasets and fine-tuning open-source models (such as Llama-3 or Mistral) on national curriculum textbooks and regional student scripts. By fostering a local ecosystem of AI developers and researchers, Bangladesh can ensure that the "intelligence" used in its schools is culturally resonant, linguistically accurate, and pedagogically aligned with the 2022 Competency-Based Curriculum. This shift ensures that the digital transformation is not an external imposition but an internally driven evolution.

➤ *Institutional Frameworks: Establishing the AI-in-Education (AIEd) Research Hub*

The fragmentation of current AI initiatives—split between the ICT Division's a2i, the Ministry of Education, and private EdTech startups—requires a centralized, institutional anchor. We propose the establishment of a "National AI-in-Education Research Hub" (NAIERH) under the joint jurisdiction of the Ministry of Education and the NCTB. This hub would serve three primary functions: first, as a regulatory body to establish data privacy and ethical guidelines for student data; second, as a technical incubator for "Bangla-NLP" tools tailored for automated grading and intelligent tutoring; and third, as a bridge between academic research and classroom implementation. Such an institution would prevent "pilot fatigue" by ensuring that successful AI experiments are systematically scaled across the 20,000+ secondary institutions in the national stream, providing a unified roadmap that transcends individual political or commercial interests.

➤ *Curriculum Reform: AI Literacy as a Core HSC Competency*

While the current HSC ICT syllabus introduces basic digital logic and programming, it lacks a comprehensive "AI Literacy" framework necessary for the 21st-century workforce. Strategic curriculum reform must move beyond teaching students how to use tools toward teaching them how to evaluate and co-create with AI. This includes integrating modules on "Prompt Engineering," "Algorithmic Bias," and "AI Ethics" into the mandatory HSC ICT subject. Furthermore, AI literacy should not be siloed within the ICT lab; it must be treated as a cross-disciplinary competency. For instance, students in the Humanities stream should explore the ethical implications of AI on society, while Science stream students should utilize AI for data modeling in physics and biology. By embedding AI literacy as a core competency, Bangladesh can ensure that its secondary graduates are not just "digitally literate" but "AI-ready," capable of navigating a global economy where human-AI collaboration is the standard.

IX. CONCLUSION

The integration of Artificial Intelligence within Bangladesh's national secondary and higher secondary education sectors represents more than a mere technological upgrade; it is a critical pivot toward pedagogical equity. As this review has demonstrated, the current "Digital Divide" is not an insurmountable barrier but a unique opportunity for a "Digital Leap." By bypassing traditional, resource-heavy infrastructure in favor of localized, offline-capable Edge AI and Small Language Models (SLMs), Bangladesh can democratize access to personalized learning for the millions of students currently underserved by the national stream.

The transition from a "Smart Bangladesh" vision to a classroom reality requires a move away from the "Hardware Fallacy" toward a strategy centered on linguistic sovereignty and teacher-AI collaboration. This review concludes that while the technological tools—such as BanglaBERT for automated assessment and predictive analytics for dropout

prevention—are within reach, their success depends on the establishment of robust ethical frameworks and a commitment to "Human-in-the-Loop" co-teaching models.

There is an urgent need for the academic community to pivot its focus. While research into AI at the tertiary level is abundant, the "Research Blind Spot" regarding the NCTB secondary stream remains a significant threat to national progress. We call upon researchers, policy-makers, and domestic EdTech innovators to prioritize the public secondary stream. The future of Bangladesh's knowledge economy will not be decided in the laboratories of private universities, but in the crowded classrooms of rural government schools. Only by bridging the pedagogical and digital divide in these foundational years can we ensure that the promise of AI serves as a catalyst for a truly inclusive and "Smart" nation.

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