

## Exploring the Integration of Adaptive Learning Technologies within Blended Learning Environments and Their Effect on Student Achievement

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ARTICLE DETAILS	ABSTRACT
Research Paper	The integration of adaptive learning technologies (ALT) within
Accepted: 12-04-2025	blended learning environments offers a transformative approach to
<b>Published:</b> 10-05-2025	addressing diverse learner needs in Indian education. This study synthesizes secondary data from 32 studies (2020–2025) to examine
Keywords:adaptivelearningtechnologies,blendedlearning, Indian education,studentachievement,technology integration	ALT's impact on student achievement in secondary and higher education across urban and rural India. Using test scores, pass rates, and engagement metrics, we found that ALT-enhanced blended learning improves achievement by $12-18\%$ (Cohen's d = 0.45-0.62), with mathematics and science showing the highest gains. Rural students benefited significantly, though digital infrastructure gaps and
	teacher readiness pose challenges. This study, examining ALT's impact across India's diverse educational contexts, underscores the need for policy interventions to enhance infrastructure and teacher training. Recommendations include prioritizing rural digital access and integrating ALT-focused teacher training into the National Education Policy (NEP) 2020.

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#### Introduction

India's education system, serving over 250 million school students and 40 million in higher education, faces challenges in addressing diverse learning needs and resource constraints (All India Survey on Higher Education [AISHE], 2023; Ministry of Education, 2024, p. 15). Traditional classrooms often struggle to personalize instruction, particularly in rural schools. Hybrid instructional models, integrating

in-person and digital teaching, alongside personalized learning systems (PLS) that leverage AI to customize content for individual students, provide a compelling approach to educational challenges. ALT supports differentiated instruction by adjusting content difficulty and pacing, while blended learning enhances engagement through digital resources.

The National Education Policy (NEP) 2020 promotes technology-driven education, with platforms like DIKSHA and ALT tools like BYJU'S gaining traction. However, the impact of combining ALT with blended learning on student achievement—defined as improvements in test scores and pass rates—remains underexplored in India's diverse landscape. By examining regional disparities and subject-specific outcomes, this research offers a novel perspective on how technology can bridge educational inequities in India's diverse landscape by addressing three questions:

- 1. How does ALT integration affect student achievement in Indian secondary and higher education?
- 2. What are the facilitators and barriers to implementing ALT in blended learning settings?
- 3. How can policy maximize ALT's benefits for diverse learners?

#### Methodology

This study used a secondary data analysis approach, reviewing peer-reviewed studies, institutional reports, and education databases from 2020-2025. Inclusion criteria focused on higher education settings, use of adaptive learning technologies in blended environments, and measurable outcomes on student performance. Data were thematically synthesized and compared to identify key patterns and trends.

#### **Data Collection**

Data were sourced from:

- **Peer-Reviewed Studies (2020–2025)**: Articles from journals like *Computers & Education* and *Journal of Educational Technology Systems*, accessed via Google Scholar and ResearchGate.
- Government Reports: Government Reports: Ministry of Education (2024). National Education Policy Implementation Report; NCERT (2024). Digital Learning Impact Assessment; ASER Centre (2023). Annual Status of Education Report 2023. [http://www.asercentre.org/reports/2023]



- Institutional Databases: Data from IIT Kharagpur, Delhi University, and state education boards.
- EdTech Reports: Case studies from BYJU'S, Embibe, and DIKSHA.

Search terms included "adaptive learning technologies," "blended learning," and "Indian education," with filters for 2020–2025. Only studies with empirical data (e.g., test scores) were included.

## Sampling

The sample comprised data from 32 studies and reports, covering approximately 120,000 students across secondary (Classes 9–12) and higher education (undergraduate programs) in India. The sample included:

- Geographic Diversity: Urban (Delhi, Bangalore), semi-urban (Bhopal, Jaipur), and rural (Odisha, Bihar).
- Subject Areas: Mathematics, Science, and English.
- Institution Types: Government schools, private schools, and universities.
- ALT Platforms: BYJU'S, Embibe, Smart Sparrow, DIKSHA.

Inclusion required quantitative outcomes and Indian relevance. Non-Indian studies were excluded. Thematic saturation was achieved when no new themes emerged after reviewing 30 studies, with two additional studies confirming consistency.

## **Ethical Considerations**

Since this study used secondary data, no direct human participants were involved, eliminating the need for informed consent or ethical approval for primary data collection. Data were sourced from publicly available, anonymized datasets to protect student privacy. Compliance with data usage policies of platforms such as DIKSHA was ensured, along with adherence to APA ethical guidelines for secondary data analysis. Potential biases in source studies (e.g., urban-centric data) were acknowledged and mitigated by including diverse geographic and socioeconomic contexts.

## Analysis

Data were analyzed using a mixed-methods approach to synthesize quantitative and qualitative findings:

• Quantitative Analysis: Academic performance metrics (e.g., test scores, pass rates) were aggregated to calculate mean improvements in student achievement. Descriptive statistics



(means, standard deviations) and effect sizes (Cohen's d) were computed using SPSS v.27. For instance, pre- and post-test scores from ALT interventions were compared across studies.

- Qualitative Analysis: Thematic analysis was conducted on qualitative data from reports and case studies to identify facilitators and barriers. NVivo software was used to code themes like "digital infrastructure," "teacher training," and "student engagement."
- Integration: Quantitative outcomes were triangulated with qualitative themes to provide a holistic understanding of ALT's impact.

This study's unique triangulation of quantitative metrics with qualitative themes from diverse Indian contexts distinguishes it from prior global meta-analyses of adaptive learning. Studies with incomplete datasets or methodological flaws were excluded.

## Results

## **Quantitative Findings**

The integration of adaptive learning technologies (ALT) within blended learning environments significantly enhanced student achievement across various metrics. As presented in Table 1, test scores increased by 12-18% (Cohen's d = 0.45-0.62) compared to non-ALT settings. For example, studies of secondary students in Odisha using platforms like Embibe reported mathematics score improvements of approximately 10–20% (ASER Centre, 2023; Toppr, 2024).

Subject-specific analyses revealed notable differences. Mathematics and science test scores improved by 14–18%, with science pass rates rising by 16% in a Delhi University study (2024). English test scores showed smaller gains of 10–12% (National Council of Educational Research and Training [NCERT], 2024). Rural students using the DIKSHA platform achieved a 13% score increase, while urban students, benefiting from better internet access, saw a 16% improvement. Additionally, student engagement, measured by task completion rates, increased by 20–25% (BYJU'S, 2023).

#### Table 1

## Impact of Adaptive Learning Technologies on Student Achievement, 2020–2025



Metric	Sample Size	Mean Score Increase (%)	Effect Size (Cohen's d)	Source
Mathematics	45 000	15	0.52	ASER Centre, 2023;
Wathematics	43,000	15	0.32	BYJU'S, 2023
Science	40,000	16	0.58	Delhi University, 2024
English	35,000	11	0.45	NCERT, 2024
Overall	120.000	14	0.50	A some soft of studies
Achievement	120,000	14	0.30	Aggregated studies

Note. Effect sizes were calculated using pre- and post-intervention test scores. Sources were aggregated from secondary data studies conducted between 2020 and 2025.

The effectiveness of adaptive learning technology (ALT) platforms in Indian education varies based on their features and accessibility. Table 2 compares three prominent platforms—BYJU'S, Embibe, and DIKSHA—focusing on core features, urban and rural accessibility, and academic outcomes. BYJU'S and Embibe, with AI-driven personalization and exam-focused content, respectively, achieved higher score increases (14–18%) but showed moderate rural accessibility due to internet dependency (ASER Centre, 2023; BYJU'S, 2023). DIKSHA, with offline access and multilingual support, demonstrated high rural accessibility and a 12–14% score increase (Ministry of Education, Government of India, 2024).



## Comparison of Adaptive Learning Technology Platforms in Indian Education, 2020–2025

Platform	Core Features	Urban Accessibility	Rural Accessibility	Academic Outcome (% Increase)
BYJU'S	AI-driven personalization, interactive videos, multilingual content	High	Moderate	14–16
Embibe	Adaptive practice, exam- focused content, offline option	High	Moderate	15–18
DIKSHA	Free personalized adaptive quizzes, offline access, 36 languages	Moderate	High	12–14

Note. Accessibility ratings are based on internet and device availability. Academic outcomes were derived from secondary studies conducted between 2020 and 2025. Sources include ASER Centre (2023), BYJU'S (2023), and Ministry of Education, Government of India (2024).







Note: Bar chart illustrating mean test score increases (%) for mathematics, science, and English in urban (Delhi, Bangalore) and rural (Odisha, Bihar) settings, based on aggregated data from 32 studies. Urban areas show 14–16% gains, while rural areas show 12–14% gains. (Source: Author's synthesis of ASER Centre, 2023; NCERT, 2024; Ministry of Education, 2024)

## **Qualitative Findings**

Thematic analysis identified:

- Facilitators:
  - Personalized Learning Paths: Platforms like Embibe dynamically modified content complexity to match student abilities, enhancing engagement and persistence (Verma & Jain, 2025; Vedantu, 2023).
  - Teacher Support: Institutions with ALT-focused teacher training saw better implementation. IIT Kharagpur's workshops on DIKSHA enhanced teacher efficacy by 25% (IIT Kharagpur, 2023).



- 3. **Policy Alignment**: NEP 2020's push for digital education facilitated ALT adoption, with 60% of sampled schools using DIKSHA by 2025 (Ministry of Education, 2024).
- Barriers:
  - Digital Divide: Rural schools faced unreliable internet and device shortages, limiting ALT access. ASER 2023 noted that 40% of rural students lacked smartphones for online learning.
  - 2. **Teacher Readiness**: Lack of training hindered effective ALT use. A Bihar study found that 55% of teachers felt unprepared to integrate adaptive tools (NITI Aayog, 2024).

## Discussion

As the first to synthesize ALT's impact across India's urban and rural schools, this study confirms that ALT-enhanced blended learning significantly boosts student achievement (M = 12-18%, Cohen's d = 0.45–0.62). These findings align with global research (Johnson et al., 2020) but highlight India-specific factors, such as NEP 2020's policy support and the digital divide's impact on rural access. Mathematics and science outperformed English, likely due to ALT's strength in structured subjects (Chakraborty & Sen, 2023). However, English's lower gains may also reflect limited teacher training in language-specific adaptive tools and students' varying motivation for language learning (Dixit & Sharma, 2024).

Contrary to predictions of minimal ALT impact in low-resource settings (Banerjee & Roy, 2021), rural gains were significant, driven by offline platforms like DIKSHA. Urban-biased datasets may overestimate rural outcomes, a limitation discussed below. These findings underscore ALT's potential to address India's educational inequities if implementation challenges are addressed.

#### **Practical Implications:**

- 1. **Infrastructure Investment**: Expand schemes like Digital India to ensure reliable internet and devices in rural schools.
- 2. **Teacher Training**: Develop national ALT certification programs, integrating platforms like DIKSHA into pre-service training.
- 3. **Policy Support**: Incentivize schools to adopt ALT through grants and partnerships with EdTech firms.



4. **Equity Focus**: Prioritize low-income and rural regions in ALT rollout to reduce educational disparities.

## Limitations:

- Secondary data reliance limits control over study design and variable consistency.
- Urban bias in some datasets may skew findings.
- Long-term impacts (e.g., retention, employability) were not assessed due to data constraints.

Future research should explore longitudinal effects and compare ALT platforms to identify the most effective tools for Indian learners.

## Conclusion

Combining ALT with hybrid classrooms fosters innovative, tailored learning experiences that hold immense potential for transforming Indian education. The analysis of secondary data from 2020–2025 reveals that ALT improves student achievement by 12–18%, with significant gains in mathematics, science, and rural settings. Facilitators like personalized learning and policy support drive success, but barriers such as the digital divide and teacher readiness require urgent attention.

For India to realize the full benefits of ALT, stakeholders must act collaboratively:

- **Policymakers** should prioritize digital infrastructure and teacher training in NEP 2020 implementation.
- Educators must embrace ALT as a tool to personalize learning, supported by professional development.
- EdTech Providers should design affordable, offline-capable platforms for rural learners.

By addressing these challenges, India can harness ALT to create an inclusive, equitable education system that empowers every learner to thrive. For adaptive technologies to truly support learning, their integration must go beyond installation and be rooted in pedagogical strategy and continuous support. As blended learning becomes more mainstream, the thoughtful use of adaptive systems can help close learning gaps—if aligned well with instructional goals.



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