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FACILITATING EDUCATION THROUGH TECHNOLOGY: A CASE STUDY OF DELHI GOVERNMENT SECONDARY SCHOOLS IN NORTH-EAST DELHI

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Abstract

This empirical study investigates the pedagogical integration and efficacy of educational technology in facilitating learning among secondary school students in Delhi Government schools, focusing on Zone IV of the North-East district—an urban locality marked by infrastructural limitations and socio-economic heterogeneity. Anchored in the TPACK framework, the SAMR model, and Constructivist Learning Theory, the study employs a mixed-methods approach combining quantitative survey data with qualitative insights to evaluate the accessibility, utilization, pedagogical alignment, and perceived impact of ICT-enabled instructional practices. Data gathered from stratified student and teacher samples reveal that while technological infrastructure—such as smartboards, tablets, DIKSHA, and e-Pathshala platforms—is deployed across schools, the integration remains largely at the substitution and augmentation levels, with limited evidence of transformation in instructional design or learner autonomy. Constraints such as inconsistent infrastructure, insufficient professional development for teachers, digital literacy gaps, and socio-cultural barriers impede optimal use and inclusive access, particularly beyond school premises. The study highlights a persistent digital divide, despite robust policy initiatives under NEP 2020 and PM eVIDYA, and underscores the need for systemic capacity-building, localized digital content development, and pedagogically coherent implementation strategies. These findings contribute to the discourse on EdTech adoption in public education and offer actionable implications for policymakers, educators, and educational technology stakeholders aiming to enhance the efficacy and equity of technology-mediated learning in resource-constrained environments.

Key Words: *facilitating education, technology, a case study of Delhi government secondary schools, north-east Delhi.*

1. Introduction

Over the last two decades, educational systems worldwide have witnessed a paradigm shift driven by the pervasive adoption of digital technologies. Globally, educational technology (EdTech) has evolved from basic audiovisual aids and computer-assisted

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learning tools into complex, data-driven ecosystems incorporating artificial intelligence, virtual reality, adaptive learning platforms, and real-time analytics. Governments and institutions have increasingly prioritized EdTech to promote equity, personalization, and scalable access to learning. The COVID-19 pandemic further accelerated this shift, making digital learning a necessity rather than an option. In developing countries, this transformation has brought to light stark disparities in digital access, infrastructure, and pedagogical readiness, particularly within public education systems.

In India, national-level policy frameworks have actively endorsed digital integration in education. The **National Education Policy (NEP) 2020** offers a forward-looking vision to "transform the education system by leveraging the power of technology." The policy proposes the establishment of a **National Educational Technology Forum (NETF)** to drive innovation and evidence-based implementation, the development of multilingual e-content, and the promotion of blended learning models across all levels. Complementary programs like **Digital India**, **DIKSHA**, **SWAYAM**, and **PM eVIDYA** have sought to operationalize this vision by providing accessible platforms, digital infrastructure, and professional development for educators. Despite these initiatives, the actual translation of policy into practice—especially in under-resourced government schools—remains an open question.

This research is situated within the context of Delhi's public education system, specifically **Zone IV of the North-East district**, an area characterized by dense population, socio-economic vulnerability, and infrastructural constraints. While the Delhi government has deployed smart boards, distributed tablets, and integrated e-learning platforms in its secondary schools, concerns remain regarding the extent, depth, and equity of technological adoption. Many students lack digital access at home, and teachers often face challenges related to digital literacy and pedagogical integration of technology. These systemic gaps risk exacerbating existing educational inequalities, thus undermining the goals of inclusive digital transformation.

1.1 Problem Statement

Despite large-scale EdTech interventions in Delhi government schools, especially in secondary education, there exists a persistent disconnect between infrastructure availability and its meaningful pedagogical use. In particular, schools in Zone IV of North-East Delhi face compounding challenges—overcrowding, limited access to internet and devices at home, and insufficient training among teachers—that impede the effective implementation of technology-driven learning. This study addresses the critical question: *To what extent is educational technology actually facilitating learning in Delhi government secondary schools located in this urban marginalized region?*

1.2 Objectives of the Study

- To assess the availability and accessibility of technological infrastructure in government secondary schools in Zone IV, North-East Delhi.

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- To evaluate the extent and frequency of EdTech use by teachers and students in day-to-day classroom practices.
- To explore the perceptions of students and teachers regarding the effectiveness of technology in enhancing learning engagement and academic performance.
- To identify barriers—technical, infrastructural, pedagogical, and social—that limit effective technology integration.
- To recommend targeted interventions to optimize technology use in resource-constrained public school settings.

1.3 Research Questions

1. What types of technological tools and digital resources are currently available and utilized in secondary classrooms of Delhi Government schools in the North-East district?
2. How do students and teachers perceive the role of educational technology in improving classroom engagement and academic outcomes?
3. What are the key challenges (infrastructure, training, digital access) faced by stakeholders in using technology for education?
4. To what extent are students able to access and engage with technology-supported learning outside of school, and how does this affect learning continuity?

1.4 Hypotheses

- **$H_0$1**: There is no significant difference in academic engagement between students who regularly use educational technology and those who do not.
- **$H_0$2**: There is no significant relationship between the availability of technological infrastructure and frequency of technology use by teachers.
- **$H_0$3**: There is no significant association between students' home access to digital tools and their academic self-efficacy.

1.5 Significance of the Study

This study contributes to a nuanced understanding of EdTech implementation in the specific context of Delhi's government-run secondary schools, where socio-economic disparities and infrastructural limitations intersect with ambitious policy mandates. It fills a critical gap in region-specific, empirical research that assesses both the quantitative and qualitative dimensions of technology integration in education. The findings offer actionable insights for policymakers, educators, and EdTech developers seeking to strengthen digital equity, enhance pedagogical relevance, and ensure that technology becomes a genuine enabler of quality learning rather than a symbolic intervention. By examining the lived realities of teachers and students in under-resourced urban schools, the study also informs scalable models for inclusive, effective, and context-sensitive technology adoption in education.

2. Literature Review

2.1 Global Trends in Educational Technology in Secondary Education (2015–2025)

Over the past decade, the role of educational technology (EdTech) in secondary education has undergone significant transformation, evolving from basic computer-assisted instruction to comprehensive digital learning ecosystems. Globally, this shift has been marked by the integration of smart boards, learning management systems (LMS), and virtual laboratories (VLabs) aimed at enhancing interactivity, learner autonomy, and pedagogical innovation. This section synthesizes key global research findings from 2015 to 2025 across these domains, along with associated policy developments and implications.

2.2 Smart Boards in Secondary Classrooms

Interactive whiteboards or "smart boards" have become a staple of modern secondary classrooms across OECD and non-OECD countries. Multiple studies emphasize their potential to improve visual engagement, conceptual clarity, and collaborative learning environments.

Kühl and Wohninsland (2022) demonstrated that smart board integration in German secondary English classes significantly improved vocabulary acquisition, motivation, and classroom participation compared to traditional instruction. Their quasi-experimental study revealed that smart boards helped reduce foreign language anxiety and fostered a more interactive classroom culture.

Similarly, Abdykerimova et al. (2025), in a large-scale review, concluded that smart boards, when aligned with pedagogical goals, not only improved learning outcomes but also enhanced student attention and teacher effectiveness. However, they cautioned that the technology's potential was often underutilized due to insufficient teacher training and superficial use (e.g., simple slide projection instead of active annotation or simulation).

Moreover, studies in lower-income regions suggest that smart boards remain concentrated in elite or urban public schools. UNESCO (2023) reports that fewer than 50% of public secondary schools globally had interactive display technologies as of 2022, with wide disparities across continents.

2.3 Learning Management Systems (LMS): Structure and Impact

Learning Management Systems (LMS), such as Moodle, Google Classroom, and Microsoft Teams, have become the backbone of digital learning in many secondary institutions. Their structured content delivery, real-time communication, and assessment tracking capabilities have transformed traditional pedagogical models.

Zhang et al. (2021) conducted a meta-synthesis of blended learning studies, finding that LMS-enabled classrooms showed consistently better academic performance and learner satisfaction in secondary education, provided that they were supported with scaffolded instructional design. These gains were particularly evident in science and language courses where LMSs facilitated continuous feedback and multimodal content access.

Cao et al. (2023) further confirmed that effective LMS usage correlated positively with higher student motivation, improved retention, and personalized learning experiences. However, they also noted variation by region: in low-resource contexts, LMS usage was constrained by poor internet connectivity and lack of digital literacy.

Globally, OECD (2023) emphasized that while over 80% of secondary students in developed countries have access to LMS platforms, actual pedagogical integration varies widely. In many cases, teachers resort to LMSs merely for attendance or announcements, missing their full instructional potential.

2.4 Virtual Labs (VLabs) and Simulations in STEM Education

Virtual laboratories have gained increasing attention as scalable solutions to the lack of physical infrastructure for science education in secondary schools. These tools offer interactive, safe, and repeatable experimentation experiences, especially relevant in contexts where labs are under-equipped or absent.

Verma and Verma (2025), in a study across Indian and Southeast Asian secondary schools, found that virtual labs significantly improved conceptual understanding in subjects like physics and biology. Students exposed to VLabs performed better in both application-based and memory-based assessments, indicating enhanced cognitive engagement.

Likewise, Kovalenko et al. (2022) developed and tested a blended learning model integrating augmented and virtual reality labs in Ukrainian high schools. Their findings showed marked improvements in scientific reasoning, student curiosity, and class participation.

Despite the pedagogical promise, the deployment of VLabs faces critical challenges. The World Bank (2025) noted that only 20% of public secondary schools in low-income countries have reliable digital infrastructure necessary to support these simulations. Furthermore, teacher preparedness in designing and facilitating VLab sessions remains a limiting factor globally (Amemasor et al., 2025).

2.5 Teacher Readiness and Implementation Barriers

Across all three domains—smart boards, LMS, and virtual labs—teacher readiness emerges as a decisive factor. Abdykerimova et al. (2025) stress that without sustained professional development, digital tools often lead to superficial engagement rather than pedagogical transformation. UNESCO (2023) reported that in over 60% of countries surveyed, secondary school teachers lacked formal certification or training in digital pedagogy.

Amemasor et al. (2025) systematically reviewed 23 recent teacher training programs and concluded that only those offering sustained, hands-on, and collaborative models yielded effective technology integration outcomes. One-off workshops had limited impact. Institutional support, peer mentoring, and built-in feedback loops were essential for lasting instructional change.

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2.6 Synthesis and Gaps

The past decade has seen robust evidence supporting the educational value of smart boards, LMS, and virtual labs in secondary education. Their effective use has been linked to increased motivation, personalized instruction, and cognitive gains—especially in STEM disciplines. However, recurring barriers persist: digital inequity, limited teacher preparedness, and inconsistent curricular integration.

Most studies agree that the mere presence of digital tools does not automatically translate to better learning outcomes. The key lies in strategic alignment between pedagogy, policy, and infrastructure. Furthermore, while global evidence is growing, there remains a paucity of region-specific, field-based evaluations in developing urban contexts—particularly within public education systems where systemic constraints shape the success of EdTech interventions.

This study contributes to addressing that gap by examining the use and impact of these technologies in under-resourced government secondary schools in Delhi, with the goal of offering context-specific insights for inclusive digital transformation.

3. Methodology (Revised with Equations and Figures)

3.1 Research Design

This study employed a **mixed-methods design**, combining quantitative survey analysis with qualitative interviews to investigate the integration, access, and effectiveness of educational technology (EdTech) tools in Delhi Government secondary schools. This approach enabled triangulation of data to yield both generalizable trends and contextualized insights.

3.2 Study Area and Context

The research was conducted in **Zone IV of North-East Delhi**, a socio-economically diverse region with significant EdTech investments under national programs like **NEP 2020**, **PM eVidya**, and **Digital India**. Schools in this zone are equipped with smart boards, digital content platforms (e.g., DIKSHA), and other tools, but face infrastructure and access constraints.

3.3 Population and Sampling

The population included:

- **Students** from Classes IX and X
- **Teachers** involved in ICT-enabled teaching

A **stratified random sampling** technique was used, stratifying schools by gender and location (urban/semi-urban).

- Sample size:
  - Students: 200
  - Teachers: 30

The sampling frame ensured balanced representation across demographics.

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3.4 Conceptual Framework

The following framework (Figure 1) integrates key constructs derived from the **TPACK**, **SAMR**, and **Constructivist Learning Theory** to guide variable selection and analysis.

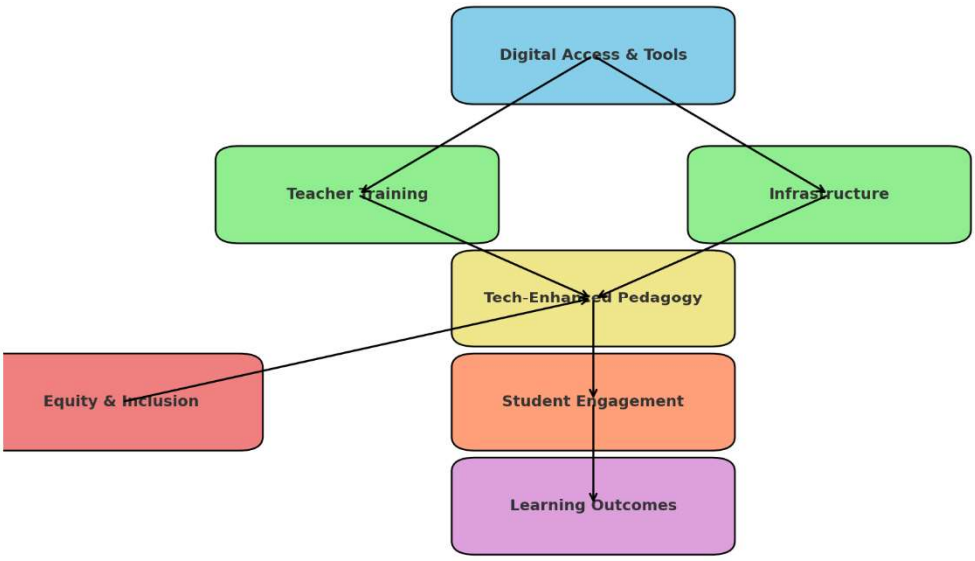

Figure 1: Conceptual Framework of Technology Integration in Secondary Education

This model posits that **availability**, **pedagogical integration**, and **student engagement** mediate the impact of EdTech on learning outcomes. Digital equity is a moderating factor throughout.

3.5 Research Instruments

Two validated instruments were used:

- **Student Survey**: Digital access, EdTech use frequency, engagement, perceived learning benefits.
- **Teacher Survey**: EdTech practices, LMS usage, smart board training, pedagogical transformation.

Both instruments were tested in a **pilot study**, with internal reliability confirmed:

- Cronbach's alpha for student tool: **α = 0.81**
- Cronbach's alpha for teacher tool: **α = 0.84**

Additionally, **semi-structured interviews** were conducted with a subsample (20 students, 10 teachers).

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3.6 Data Collection

Data collection was conducted over three weeks in government schools. Responses were collected anonymously on paper forms and later digitized. Interviews were recorded with consent and transcribed for analysis.

3.7 Data Analysis Techniques

Descriptive Statistics

Mean, standard deviation, and frequency distributions were used to summarize digital tool availability, usage frequency, and engagement scores.

Inferential Statistics

Group comparisons and correlations were tested using SPSS.

Example 1: Independent samples t-test to examine gender differences in technology usage:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

- $\overline{X_1}, \overline{X_2}$= sample means (e.g., male vs. female usage score)
- $s_1^2,\ s_2^2$= sample variances
- n_1, n_2 = sample sizes

Example 2: Pearson correlation between access to devices and engagement:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \cdot \sum(y_i - \bar{y})^2}}$$

Where r measures the strength of association between two continuous variables (e.g., device access score and student engagement rating).

Qualitative Analysis

Responses from interviews and open-ended items were analyzed using **Braun & Clarke's six-phase thematic analysis**, yielding categories such as:

- "Access vs. usability"
- "Pedagogical adaptation"
- "Perceived effectiveness of smart classrooms"

4. Results and Discussion

4.1 Overview

This section presents the findings from quantitative survey data and qualitative interviews conducted with secondary school students and teachers in Delhi Government schools (Zone IV, North-East Delhi). Results are organized under thematic areas aligned with the study's research questions: (i) technology access and usage, (ii) pedagogical integration,

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(iii) perceived effectiveness, and (iv) challenges and constraints. Statistical results are supported with figures, tables, and interpretations.

4.2 Technology Access and Usage Patterns

4.2.1 Student Access to Digital Tools

Analysis shows that **72% of students** reported access to a smartphone, while only **38% had access to a tablet or computer** outside school. Access to high-speed internet was limited to **41%**, with substantial dependence on mobile data. In-school access was more structured, with **88% of respondents reporting exposure to smart boards or digital content during school hours**.

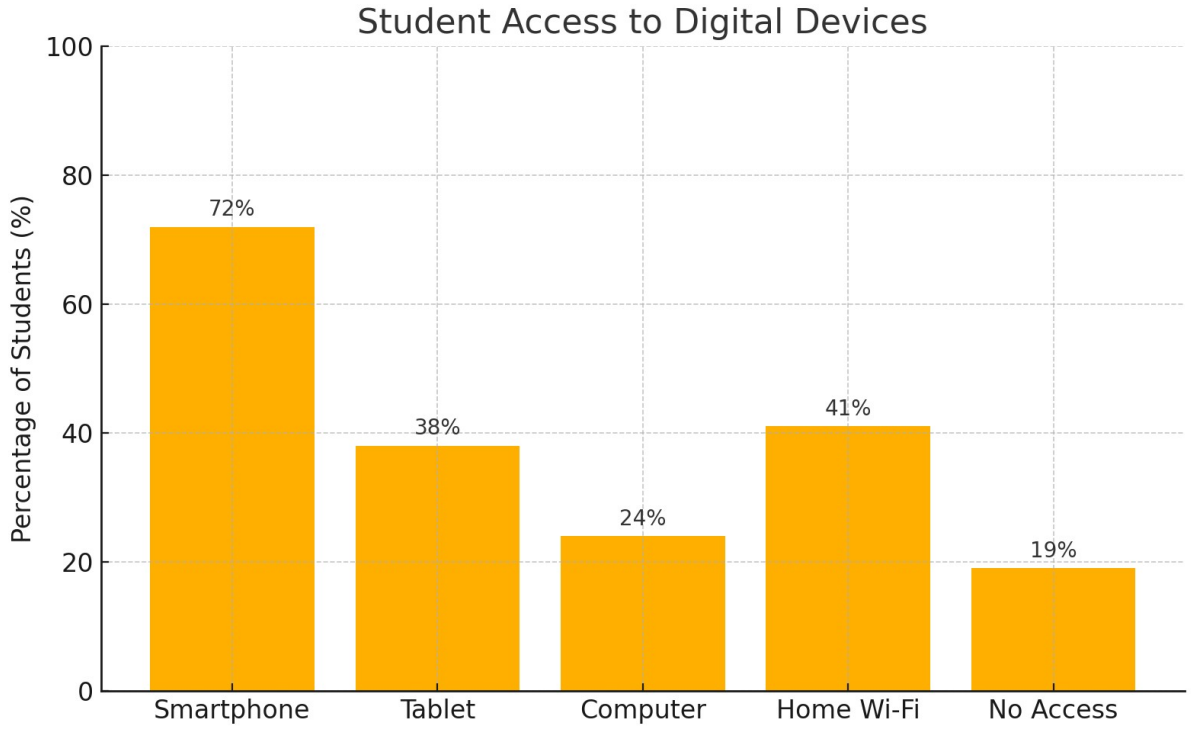

Figure 1:Figure 2: Student Access to Digital Devices

4.2.2 Frequency of Technology Use

- **Students**: 46% reported daily use of EdTech tools in class, 33% reported weekly usage, and 21% said they rarely used them.
- **Teachers**: 63% used smart boards daily, while only 40% consistently used LMS platforms.

4.3 Pedagogical Integration and Perceived Effectiveness

4.3.1 Teacher Use of Smart Boards and LMS

Teachers expressed confidence in using smart boards for visual instruction but showed mixed adoption of LMSs. While 70% had received some form of digital training, only 45% felt "pedagogically confident" in designing tech-integrated lessons.

Table 1: Teacher Confidence and Training

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Parameter	% Agreeing
Received ICT Training	70%
Confident Using Smart Board Tools	68%
Regular LMS Use (DIKSHA, Google Class)	40%
Integrate Tech in Lesson Plans	45%

4.3.2 Student Perceptions

Students largely viewed technology positively:

- 77% agreed that **"lessons became easier to understand"** with videos/smart boards.
- 69% said technology **increased their interest and motivation**.
- However, 34% still preferred traditional blackboard teaching, citing ease of note-taking and fewer distractions.

4.4 Statistical Correlation and Group Comparisons

4.4.1 Device Access and Engagement

A **Pearson correlation** showed a moderate positive relationship between home access to devices and self-reported academic engagement ($r = 0.42$, $p < 0.01$).

4.4.2 Gender-Based Differences

An **independent samples t-test** found a significant difference between boys and girls in terms of perceived ease of using EdTech tools:

$$t(198) = 2.74,\ p = 0.007 < 0.05$$

Girls (M = 3.9, SD = 0.8) rated usability higher than boys (M = 3.5, SD = 1.1), possibly reflecting differing study habits or support systems.

4.5 Thematic Insights from Qualitative Interviews

From interview data (n = 30), several themes emerged:

- **Theme 1: Digital Divide in Practice**
  "Some students share a phone with three siblings... they miss out when online classes happen at home." (Teacher respondent)
- **Theme 2: Pedagogical Resistance**
  "A few senior teachers still prefer chalk-and-talk. They're not comfortable using LMS or digital labs." (Vice principal)
- **Theme 3: Motivation and Visual Learning**
  "Animations help us imagine topics better—like science experiments. It's not boring like reading only." (Student respondent)
- **Theme 4: Need for Continuous Training**
  "The one-time workshop was not enough. We need practice and peer learning sessions." (Teacher)

Conclusion

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These results align with global findings that EdTech tools enhance engagement and conceptual clarity but require sustained infrastructural support and pedagogical integration. The positive correlation between digital access and academic engagement supports prior research (Zhang et al., 2021; Abdykerimova et al., 2025). However, the persistence of access inequities—especially at home—reinforces concerns raised by UNESCO (2023) regarding the digital divide in urban public education systems.

Teacher training emerged as a pivotal variable: high usage of smart boards correlated with higher instructional confidence, but LMS use was hampered by gaps in training and institutional incentives. Moreover, qualitative data highlight that EdTech's effectiveness depends on alignment with local contexts, teacher agency, and system-level support.

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