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Punjab case study on technology access and educational inequality in Indian education

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Abstract

India's emergence as one of the world's rapidly expanding digital economies is supported by governmental policies like Digital India and NEP 2020, which highlight technology's transformative potential to improve educational equity and quality. However, the COVID-19 pandemic has accelerated digital learning while exposing persistent and systemic disparities. This Punjab case study reveals that rural and marginalized populations, broadly representative of India's diversity, continue to experience limited device ownership, inadequate connectivity, and low digital proficiency. These factors contribute to a divided education system where low-income, rural, and female students face considerable disadvantages. Despite extensive policy efforts, nearly half of Indian households remain offline, underscoring the vast scope of the challenge. This research investigates how unequal technology access affects education outcomes in Punjab and evaluates strategies aimed at narrowing digital gaps to achieve greater educational equity in India.

Keywords: Digital divide, educational inequality, access to technology, digital literacy, NEP 2020, socioeconomic disadvantages, rural education, digital inclusion

Introductions

India continues to place technology at the center of its educational transformation, as reflected in flagship initiatives such as NEP 2020 and Digital India. The growth of online learning platforms, MOOCs, and digital classrooms, especially propelled by the COVID-19 crisis, marks an ongoing digital shift in education.

Despite substantial investments, Punjab is marked by persistent inequalities in digital access and capacity. Urban schools often benefit from high-speed internet and skilled teachers, whereas rural schools struggle with poor connectivity and limited digital literacy among educators and learners. Research indicates that this divide excessively affects rural, economically disadvantaged, and female students—disseminating systemic inequalities and creating a stratified education system that favors more privileged groups (Sharma *et al.*, 2024; Singh & Kaur, 2024) ^[18, 19].

Around half of Indian households still lack internet connectivity, with rural and tribal populations facing pronounced exclusion. Further, the pandemic magnified these disparities as urban students adapted relatively quickly to online education, while marginalized groups experienced setbacks in learning opportunities (Gulzar, 2024; Amjad, 2024) ^[6, 22]. The technological gap significantly impacts academic performance, reducing educational persistence and limiting career prospects among disadvantaged learners (Hasan & Bao, 2020) ^[8].

Moving beyond access alone, the fundamental challenge lies in ensuring fair learning opportunities and student engagement. This study, focusing on Punjab, explores how technological inequities shape educational outcomes and examines evidence-based approaches to bridge the digital divide, promoting educational inclusion locally and across the wider Indian education system.

Study Significance

Equity in education is recognized as a human right and a main vision of NEP 2020, with digital access crucial for reducing inequalities and supporting social mobility in India (Ministry of Education, 2020; Sharma *et al.*, 2024) ^[14, 18]. Yet infrastructural deficits, high costs, and socio-cultural barriers continue to constrain digital learning, particularly in

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resource- limited regions such as Punjab (Moloi *et al.*, 2023; Singh & Kaur, 2024) ^[15, 19]. Global evidence, including South Africa's experience, highlights that digital inequality reflects social divisions such as class, gender, and geography, showing the importance of context-specific strategies (Dube *et al.*, 2023; Mutongoza & Olawale, 2022) ^[5, 16].

However, despite growing national research on the digital divide, Punjab remains underexplored, especially in terms of how infrastructure, socio-economic status, caste, language, and teacher readiness interact to shape digital inclusion. This lack of region-specific evidence represents a critical research gap that limits policy responsiveness at the state level. Addressing this gap, the present study examines Punjab's unique challenges and opportunities, offering practical insights that extend beyond infrastructure to emphasize teacher training, context-relevant curricula, and community participation. Its contribution lies in demonstrating how locally grounded, holistic approaches can bridge digital divides and prepare learners to thrive in India's knowledge economy.

Literature Review

Inequality in educational technology encompasses more than mere availability of devices and internet access; it also involves differences in digital skills and the uneven socio-economic advantages drawn from technology use, which together perpetuate exclusionary cycles (Azionya & Nhedzi, 2021; Mutongoza & Olawale, 2022; Hasan & Bao, 2020) ^[2, 16, 8]. The acceleration to online learning during the COVID-19 pandemic amplified existing inequities, especially impacting rural and marginalized populations in India. Punjab serves as a clear example where cost barriers, inadequate infrastructure, and limited digital competencies have restricted students' ability to engage in learning activities (Kelly & Zakrajsek, 2023; Czerniewicz *et al.*, 2020; Singh & Kaur, 2024; Sharma *et al.*, 2024) ^[11, 4, 19, 18]. The digital divide is increasingly recognized as complex and layered, involving not just physical access but also disparities in digital literacy and the socio-economic benefits technology confers, emphasizing that connectivity alone is insufficient for educational equity (Azionya & Nhedzi, 2021; Gulzar, 2024) ^[2, 6].

Economic and geographic factors continue to play a dominant role in shaping digital inequality. Learners from rural and low-income backgrounds frequently face challenges such as limited broadband availability, expensive data plans, and unreliable electricity. These limitations significantly reduce their participation in digital learning and widen educational outcome gaps between urban and rural students (Kelly & Zakrajsek, 2023; Kilag *et al.*, 2023; Singh & Kaur, 2024) ^[11, 12, 19]. Studies during the pandemic reveal that vulnerable groups were disproportionately hampered by digital exclusion, and although certain improvements in infrastructure may have occurred since, persistent disparities remain in regions like Punjab (Czerniewicz *et al.*, 2020; Sharma *et al.*, 2024) ^[4, 18]. Furthermore, insufficient preparedness in digital skills among students leads to diminished engagement, poorer academic results, and higher dropout probabilities (Hasan & Bao, 2020; Amjad, 2024) ^[8, 22]. Although digital platforms offer opportunities for personalized and inclusive learning, specialists underscore that to achieve true equity, technological interventions must be complemented by

effective pedagogy, tailored curricula, and supportive learning environments.

Efforts to address the digital divide span both international and national levels. South Africa's experience integrating teacher training with ICT infrastructure provides useful lessons (Dube *et al.*, 2023) ^[5]. In India, initiatives like Digital India, NEP 2020, PM e-Vidya, DIKSHA, and SWAYAM seek to broaden technology access and capacity while making education more affordable and empowered digitally (Moloi *et al.*, 2023; Kelly & Zakrajsek, 2023) ^[15, 11]. Yet, challenges such as fragmented infrastructure, low levels of teacher preparedness, and ongoing marginalization undermine the full benefits of these programs (Mutongoza & Olawale, 2022) ^[16]. Moreover, research evaluating the impact of such initiatives at the state level, such as Punjab, remains scarce (Sharma *et al.*, 2024) ^[18]. Existing literature tends to emphasize infrastructure while neglecting socio-cultural elements like caste, gender, and language and insufficiently addresses the experiences of educators and learners. Further, there is a scarcity of research on low-cost, community-driven digital solutions and the integration of technology with pedagogy and socio-emotional learning. Addressing these gaps will be essential to creating effective, context-sensitive strategies that foster inclusive digital education in Punjab and across India.

Research Rationale

India's rapid digitization requires immediate inclusivity to prevent exacerbating social cleavages (Hasan & Bao, 2020) ^[8]. The Punjab research offers socio-cultural barriers knowledge and assists in crafting appropriate strategies. It offers actionable interventions for scholars, policymakers, and practitioners for India's plural education system.

Significance

- **Academic:** Strengthens comparative scholarship by situating digital divides within India's distinct socio-economic and cultural context and closing gaps in localized research.
- **Policy:** Offers information to improve national policies, emphasizing affordability, accessibility, capacity building, and participation.
- **Practical:** Provides solutions for educators and institutions, such as digital skills training, local content development, affordable access to devices, community centers, and EdTech collaborations—fostering grassroots resilience and inclusive digital participation.

Research Objectives

This study aims to:

- Define the nature and scope of the digital divide within Punjab's education system as a representative microcosm of broader Indian educational disparities.
- Examine how inequalities in technology access affect student learning outcomes, academic engagement, and future opportunities in Punjab.
- Identify key infrastructural, affordability, digital literacy, and policy-related barriers that exacerbate educational inequalities in Punjab's digital landscape.
- Evaluate the effectiveness of existing government and institutional initiatives aimed at reducing digital disparities in Punjab's education sector.

- Propose actionable, evidence-based strategies to foster inclusive policies, community participation, and institutional practices that bridge the digital divide and promote educational equity.

Research Questions

To achieve these objectives, the study will address the following questions:

- What is the extent and variation of the digital divide within Punjab's education system, and how does this reflect wider patterns in Indian education?
- In what ways does unequal access to digital technology impact student learning, academic achievement, and future prospects in Punjab?
- What infrastructural, economic, social, and policy barriers impede equitable technology access and digital inclusion in Punjab?
- How effective are current government and institutional programs in addressing digital inequities within Punjab's education sector?
- What policy interventions and institutional practices can most effectively advance equitable and inclusive digital learning environments in Punjab and, by extension, across India?

Research Methods

Methodology

This study employs a qualitative interpretivist case study approach to investigate stakeholder perceptions of digital inequities within educational institutions in Punjab, India. Emphasizing socio-economic, cultural, and institutional factors, the research explores the complex dynamics that influence unequal technology access and its consequences for educational equity. Grounded in an interpretivist paradigm, the study seeks to understand how students, teachers, and administrators experience and navigate the digital divide in their local contexts, capturing rich, context-specific insights critical for formulating locally relevant strategies to bridge technology access inequalities in Punjab and inform broader Indian education settings.

Method Framework

The study was conducted as a qualitative case study in three heterogeneous educational institutions across Punjab: a rural government school, an urban municipal school, and a public university. These sites were purposively selected to represent Punjab's diverse socio-economic and geographic educational landscape. This framework enables an in-depth exploration of digital access disparities and institutional responses that mirror wider challenges faced across India's education system.

Sampling Method

Using purposive sampling, the study recruited 18 participants—including 8 students, 6 teachers, and 4 administrators—with direct experience in educational technology across the three institutions. Sampling continued until data saturation was reached, ensuring recurring themes and multiple perspectives reflective of realities beyond the immediate local setting, capturing challenges common nationwide.

Data Collection Methods

Data were collected over two months through:

- Semi-structured individual interviews utilizing research-informed schedules;
- Focus group discussions (FGDs) with students and teachers fostering collective reflection;
- Short classroom and online session observations for data triangulation.

Data Collection Instruments

To meet the study objectives, three complementary data collection tools were employed:

1. Semi-Structured Interview Guide

Conducted with students, teachers, and administrators, combining open-ended questions and thematic prompts addressing:

- Access to technology (devices, connectivity)
- Digital skills and literacy challenges
- Institutional support and infrastructure
- Impacts on learning, motivation, and engagement
- Awareness and perceptions of digital education initiatives (e.g., Digital India)
- Socioeconomic and cultural barriers

The guide was pilot-tested for clarity and cultural relevance.

2. Focus Group Discussion Protocol

Sessions with 5-7 participants emphasized shared storytelling on:

- Common challenges and successes in digital access
 - Gaps in resources and training
 - Suggestions to improve equity and institutional support
- Discussions were moderated to promote inclusivity and recorded with consent.

3. Observation Checklist

Documented classroom and ICT facility conditions, including:

- Types and usage of digital tools
 - Student engagement patterns
 - Infrastructure functionality and support availability
- Observations contextualized and validated self-reported data.

Data Analysis

All interviews and FGDs were audio-recorded, transcribed verbatim, and analyzed using thematic analysis following Braun and Clarke's six-step framework. This involved:

- Familiarization with data through repeated reading
- Generating initial codes using qualitative analysis software
- Searching for and reviewing themes to capture broader patterns
- Defining and naming themes to convey participant perspectives
- Producing a coherent report linking findings to research aims and literature

Rigor was strengthened through methodological triangulation, member checking, investigator cross-validation, and reflexive journaling of researcher positionality to minimize bias and enhance credibility.

Ethical Considerations

The study adhered to strict ethical protocols. Informed consent was obtained after explaining the study's purpose, procedures, and voluntary participation rights. Participant anonymity was ensured through data anonymization. Digital data were securely stored with encrypted backups and deleted after project completion. Data collection environments were designed to minimize harm and respect local customs. Ethical clearance was granted by the institutional Research Committee, ensuring participant welfare and cultural sensitivity.

Results

Analysis of interviews and focus group discussions conducted in Amritsar, Punjab, identified six interconnected themes that reflected the lived experiences of students, teachers, and administrators regarding digital access and usage across diverse educational settings. These themes emphasized structural, socioeconomic, cultural, and educational dimensions of inequality and their influence on digital participation.

The first theme concerned limited access to devices and connectivity. A majority of disadvantaged students relied primarily on smartphones for academic work, while many government schools had outdated computer laboratories and restricted internet facilities.

The second theme focused on digital literacy gaps. Urban learners and teachers displayed comparatively higher levels of computer and internet proficiency, whereas rural participants often struggled with even basic technology use. Teacher readiness across both contexts remained limited due to insufficient training opportunities.

The third theme highlighted socioeconomic and cultural barriers. High device costs and expensive internet data plans prevented sustained access for many families. Additionally, gender-related restrictions in certain communities constrained girls' ability to use smartphones and computers.

The fourth theme was the impact of technological access on learning and engagement. Students with limited access reported challenges such as disrupted online attendance and reduced motivation, whereas those with adequate access benefited from independent learning and exploration beyond textbooks.

The fifth theme revealed policy awareness and program utilization gaps. Although national initiatives such as Digital India, SWAYAM, and PM eVidya were recognized, awareness and practical usage among both students and teachers remained very limited. Obstacles included lack of localized content, insufficient support, and difficulties navigating platforms.

The sixth theme involved recommendations for bridging the divide. Participants consistently proposed affordable device distribution, subsidized internet packages, and systematic skill development workshops for both students and teachers. The synthesis of participant responses indicated that digital inequities were reinforced by economic constraints, infrastructural deficiencies, a lack of training, and restrictive social norms. These overlapping challenges demonstrated that device provision alone was insufficient; instead, holistic interventions addressing access, affordability, literacy, and socio-cultural barriers were required to foster equitable inclusion.

As Table 7 illustrates, the digital divide is reinforced by structural and social constraints that operate simultaneously. Economic hardships and infrastructural deficits limit basic access, while gaps in digital literacy and restrictive cultural norms reduce effective participation, particularly for marginalized groups such as rural students and girls. These interlocking challenges underscore why single-dimensional interventions, such as providing devices alone, are insufficient; instead, holistic measures that address access, training, affordability, and equity are needed to foster inclusive digital education.

Table 1: Access to Devices and Connectivity

Category	Findings	Supporting Data	Illustrative Quote
Device access	Majority of disadvantaged students rely on smartphones	~60% of students use mobile devices for learning	"Most of us only have mobile phones, and they're not enough for writing essays or researching online." (Student, Rural School)
Computer infrastructure	Outdated/inadequate labs in government schools	Only 57.2% of schools have computers	"Our computer lab is old and not enough to serve all the students." (Teacher, Government School)
Internet availability	Limited institutional connectivity	Only 45% of schools have internet access	—

Table 2: Digital Literacy and Skills Gaps

Category	Urban Context	Rural Context	Supporting Quote
Computer proficiency	33% of students	12% of students	"Students often ask for help with simple computer functions." (Teacher, Urban School)
Internet skills	40% of students	18% of students	"Many teachers, including myself, lack confidence in using new technologies." (Administrator, Urban School)
Home internet access	55% of households	22% of households	—
Teacher readiness	Limited professional training available	Even fewer structured opportunities	—

Table 3: Socioeconomic and Cultural Barriers

Barrier Type	Description	Quote
Economic	High cost of laptops and mobile data restricts student access	"Buying a laptop or paying for data plans is simply unaffordable for most families." (Student)
Gender norms	Cultural practices restrict girls' use of digital devices	"In some communities, girls have fewer chances to use smartphones or computers because of traditional norms." (Teacher, Rural School)

Table 4: Impact on Learning and Engagement

Access Level	Impact on Learning	Illustrative Quote
Limited access	Missed online classes, lowered motivation	“Due to internet cuts out during online classes, I miss entire lectures and have difficulty catching up.” (Student, Rural School)
Adequate access	Enhances independent learning & exploration	“When we have access, technology helps us learn independently and explore beyond textbooks.” (Student, Urban School)
Device type	64% smartphones, 21% laptops, 10% tablets	—

Table 5: Awareness and Perceptions of Policy Interventions

Policy Program/Initiative	Participant Awareness	Effectiveness Challenges	Illustrative Quote
Digital India, SWAYAM, PM eVidya	Limited awareness among students and teachers	Lack of training, navigation difficulties, and localized content gaps	“Programs exist, but many students don’t know about them or cannot use them effectively.” (Teacher, Urban School)
SWAYAM	Some students aware of courses	Lack of training/support undermines usage	“SWAYAM has good courses, but nobody teaches us how to navigate them.” (Student, University)

Table 6: Recommendations for Bridging the Digital Divide

Strategy Area	Proposed Action	Rationale / Description	Representative Quote
Affordable Access	Distribute low-cost digital devices (e.g., tablets, laptops)	Expands device ownership among economically disadvantaged students	“Distributing affordable tablets and free or subsidized data plans would make a huge difference.” (Administrator)
Connectivity Support	Provide free or subsidized internet/data plans	Removes recurring cost barriers for rural and low-income learners	“Many families cannot afford laptops or expensive data.” (Student)
Skill Development	Continuous digital skills workshops for students and teachers	Builds confidence and capacity for effective use of digital platforms	“Regular technical skills workshops for both students and teachers”

Table 7: Key Barriers to Digital Inclusion in Punjab’s Education System

Barrier	Description	Representative Quote
Economic Constraints	High cost of devices and data	“Many families cannot afford laptops or expensive data.”
Infrastructure Gaps	Outdated labs, unreliable internet	“Our school Wi-Fi is often down and computers are old.”
Digital Literacy	Lack of structured training	“We need regular workshops to improve digital skills.”
Cultural/Social Norms	Gender and community barriers	“Girls have less access to devices in our community.”

Table 8: Summary of Research Questions, Objectives, and Key Findings

Research Questions	Alignment with Research Objectives	Summary of Findings
1. What is the extent and variation of the digital divide across contexts in Punjab and broader Indian education?	Define the nature and scope of the digital divide by socioeconomic and geographic factors in Punjab as a case study for India.	Significant disparities in device ownership, internet connectivity, and digital skills exist across rural, urban, and institutional contexts in Punjab, mirroring wider Indian educational inequalities.
2. How does unequal access to technology impact learning, achievement, and future opportunities?	Investigate how technological inequality affects educational outcomes and student engagement.	Digital inequities lead to reduced academic performance, lower engagement, and limited higher education and career opportunities, particularly among marginalized groups in Punjab.
3. What are the key infrastructural, economic, social, and policy barriers to digital access in Punjab’s education system?	Identify core barriers including infrastructure deficits, affordability, digital literacy gaps, and policy shortcomings.	Barriers encompass inadequate digital infrastructure, high device and internet costs, limited digital literacy, and socio-cultural factors such as restrictive gender norms.
4. How effective are government and institutional initiatives (e.g., Digital India, NEP 2020 programs, SWAYAM, PM eVidya) in reducing digital inequalities?	Assess the effectiveness of existing programs aimed at digital inclusion in Punjab’s educational contexts.	Awareness and utilization of government programs are limited; gaps in implementation and localized content availability diminish overall effectiveness.
5. What evidence-based policies and practices can promote equitable technology access and inclusion in Punjab and Indian education?	Recommend inclusive, context-sensitive strategies for policymakers, educators, and communities to bridge the digital divide.	Key recommendations include affordable device distribution, subsidized internet access, ongoing digital literacy training, localized language content development, and multi-stakeholder collaboration.

Discussion

This Punjab-based case study underscores the multifaceted digital divide shaping educational equity. Limited device access, reliance on smartphones, weak digital skills, and entrenched socioeconomic and cultural barriers collectively restrict learning, with rural and marginalized groups most affected. Students describe disrupted learning due to poor

infrastructure, while those with better access highlight technology’s empowering potential. Low awareness and uneven uptake of government programs further reveal policy gaps. Bridging these intersecting challenges requires holistic, context-sensitive strategies that expand affordable access, strengthen digital competencies, and address social norms to ensure equitable participation in digital education.

Summary

This Punjab-centered case study underscores that bridging the digital divide requires addressing not only physical access but also digital skills and entrenched socioeconomic and cultural barriers. Integrated, culturally sensitive policies and practices are critical to achieving true educational equity in Punjab—and by extension, India's—digital education landscape.

Conclusion

This Punjab-based case study demonstrates that the digital divide in education is shaped by intersecting infrastructural, economic, literacy, and socio-cultural barriers that disproportionately affect rural and marginalized learners. Unequal device and internet access, limited digital competencies, and restrictive gender norms constrain meaningful participation in digital education, while low awareness of government initiatives highlights policy implementation gaps. Realizing the transformative potential of digital learning requires integrated, context-sensitive strategies—including affordable device and internet provision, sustained skill-building, and inclusive, gender-responsive policies—that align with NEP 2020's vision of equitable and inclusive education across India.

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