Examining Factors Influencing Technology Integration in Indian Classrooms: A Teachers' Perspective

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India is actively transitioning towards a 'digital-first' economy, bolstering digital public infrastructure in sectors like finance, healthcare, and e-commerce. Likewise, the Government of India is striving to revamp the education system, emphasizing technology integration to harness the demographic dividend. Understanding the impact of this technological shift at the grassroots level, especially from teachers' perspectives, is paramount. This study delves into the factors influencing Indian teachers' adoption of technology in education and their perceptions of its incorporation. Through a mixed-method approach involving a survey with 1,355 respondents and 20 semi-structured interviews, we uncover how education policies, the COVID-19 pandemic, and social media converge, placing teachers at the forefront of technology integration in education.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI;**

Additional Key Words and Phrases: Teacher, education, technology, challenges, India, policy, COVID-19

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1 Introduction

Over the last few years, India has been moving swiftly towards becoming a 'digital-first' economy, by extensively working towards creating digital public infrastructure across various domains, including finance, banking, healthcare, and e-commerce [38]. To realize the potential of India's demographic dividend, inclusive education is a highly prioritized developmental goal. From increased budget allocations [7] to policy-level changes [34, 37], the Indian education sector has been striving to provide equitable technology-enabled education to students, cutting across urban-rural and socio-economic divides. This thrust for technology in education comes at a time when India has

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achieved a high enrollment rate in schools [8] above 95% for the past 15 years, however with no substantial improvements in the learning outcomes of students [22, 53].

In this evolving landscape, it is crucial to understand the impact and adoption of technology infrastructures at the grassroots level. Specifically, from the teachers' perspective, who play a crucial role in the education ecosystem as facilitators of the digital transformation and serve as key connectors to students, the ultimate beneficiaries of these endeavours. **United Nations Educational, Scientific and Cultural Organization (UNESCO)** underscores the pivotal role of teachers in achieving the objectives outlined in the fourth **UN Sustainable Development Goal (SDG 4)** agenda which aims to provide equitable quality education universally [64]. There has been growing HCI research exploring teachers' application of specific tools like WhatsApp [72], the utilization of support groups for teachers [21], and stress associated with technology use [73]. However, we posit that there is a significant gap in the literature which understands teachers' perspectives on technology integration in Indian classrooms, across diverse settings encompassing rural and urban in both government and private schools. This study seeks to bridge this gap, by delving into how teachers perceive and adapt technology in their pedagogical practices. In particular, this study seeks to address the following research questions—**RQ1:** What are the factors that influenced Indian school teachers to integrate technology into teaching? **RQ2:** How do Indian school teachers perceive and adapt to the incorporation of technology in teaching? Answering these questions can offer a comprehensive understanding of the dynamics surrounding technology integration in Indian schools. These insights will aid in developing targeted interventions, policies, or training programs to further support teachers effectively.

To answer these questions, we employed a mixed-methods approach including a survey and subsequent semi-structured interviews. A total of 1,355 school teachers from across India participated in the survey. Out of them, 20 school teachers were interviewed, which represented a diverse cohort of teachers, spanning both government and private schools, as well as those affiliated with State and Central government boards of education. We investigated what their current teaching practices are, which aspects of their work they integrate technology in, what benefits they perceive, and what challenges they face. We identify three key factors that influenced technology integration within the Indian education system and thereby impacted teachers' adoption of it: (1) the onset of the COVID-19 pandemic, (2) outcomes of implementation of the **National Education Policy (NEP)** 2020 [37], and (3) influence of social media. Enforced lockdowns induced by the pandemic necessitated a rapid shift to online teaching and compelled teachers to embrace technology. Simultaneously, the introduction of NEP 2020 facilitated enhanced access to both digital and physical infrastructure, incentivizing the provision of technology-enabled education. In addition, exposure to social media and increased student demands, motivated teachers to adopt innovative teaching methodologies. Notably, our research revealed that despite the struggles, our teachers identified novel solutions with the limited resources available to them. For instance, in schools with no technology infrastructure, teachers used their personal smartphones to show content to students, in small groups of 4-5. We conclude the paper with a discussion on creating more equitable opportunities for teachers from diverse backgrounds to integrate technology in education and steps to seamlessly integrate technology in a teacher's workflow.

2 Related Work

In this section, we delve into the literature investigating the use of technology in education, both globally and specifically within India, with a focus on the classroom settings.

2.1 Technology in Education

Technology plays a pivotal role in the educational landscape, enhancing student engagement, enriching pedagogical methods for teachers, and facilitating personalized learning experiences [70].

SDG 4 [68] underscores the significance of technology in education, highlighting its multifaceted influence: serving as a resource, a delivery medium, a skill to be acquired, a tool for planning, and a provider for social and cultural context. Nevertheless, it is crucial to acknowledge that technology merely functions as a tool in the educational process. Its true potential is harnessed through the proficiency of teachers in its utilization and its effectiveness in addressing the diverse needs of students [70]. In developed countries, the relatively high levels of income, technological advancement, well-developed infrastructure, along with stable macroeconomic and political stability often translate into more resources for education [29]. For instance, the 2022-2023 UK government research report [13] involving 1,877 schools, revealed that a majority of teachers incorporated interactive whiteboards (86%), laptops (86%), desktop computers (74%), and tablet computers (65%) into their lessons. Similarly, national data from a 2019-2020 survey of 1,300 public schools in the United States showed comparable findings [23]. Hence, recent research indicates a shift towards understanding the role of cutting-edge technologies such as Augmented Reality [3, 5, 9, 16, 17, 20, 32, 56, 62] and Virtual Reality [3, 5, 20, 42, 47, 59]in education.

Furthermore, there has been an increase in the integration of **Artificial Intelligence (AI)** in education, [18, 31, 49, 57] largely attributed to the efficiency and versatility of **Large Language Models (LLMs)**. For example, Khanmigo, a GPT-4 powered educational assistant, was launched in March 2023 and has seen adoption by thousands of educators and learners across various educational institutions. These include the Khan Lab School and multiple conventional public schools in different regions of the USA [55, 67]. Additionally, Singapore's Ministry of Education is currently in the process of implementing automated grading systems for English assignments in both primary and secondary schools [60]. To accommodate the varying learning speeds among students, the Singapore government is conducting trials on an AI-driven adaptive learning system capable of evaluating student performance in real-time and adjusting their learning trajectory accordingly [63].

In contrast, in developing countries, lower income levels and lack of infrastructure can limit access to technology in education [29]. For instance, according to the UDISE report covering 1.4 million Indian schools, only 12.9% of schools had functional laptops, 9% had operational tablets, and 6.7% had computers. Despite these challenges, there are concerted efforts to integrate technology into classrooms, which we discuss below.

2.2 Technology in Indian Classrooms

Prior to the COVID-19 pandemic, a research study [39] conducted in India indicated a highly positive attitude among teachers towards the use of information and communication technology in education. Teachers perceived technology as a valuable tool for sourcing material for class preparation (91%), for their own development and studies (89%), and as a management tool for organizing work (79%). Similarly, Kaur and Singh [28] reported teachers found digital tools beneficial in retaining students' attention, enhancing student-teacher interaction, and boosting the motivation and academic performance of both teachers and students. However, both studies reported inadequate use of technology in classrooms due to limited internet access, lack of modern infrastructure, limited technical support, lack of effective training, limited time, and traditional methods of evaluation [28, 39].

Recent research studied the impact of NEP 2020 and COVID-19 on the utilization of technology for teacher training, as well as the evolving role of educational technology within Indian classrooms. In 2020, India introduced the NEP [37] which advocates for a comprehensive digital overhaul in the education sector. It places teachers at the center and recognizes the importance of prioritizing their involvement in integrating technology in classrooms [65] (we have elaborated more on NEP 2020 in Section 3.2). It resonates with the findings of Sharma [58], affirming that

optimizing technology usage involves transforming teaching methods, restructuring curricula and evaluation processes, and empowering teachers with increased autonomy. Kundu and Bej [30] conducted an evaluation of NEP's alignment with pedagogical, institutional, and human factors. They found that the policy effectively encapsulates a comprehensive approach to technology adoption, despite a few limitations. They emphasize the policy's focus on dematerializing and digitizing content, while expressing concerns about implementation challenges, particularly regarding institutional autonomy and the need for teacher skill development. However, it is important to note that these findings rely on secondary data, and the real-world application of NEP 2020's proposed strategies has not been studied. Our work tries to fill this research gap.

The COVID-19 pandemic led to the long-term closure of educational institutions, necessitating a shift to online and remote learning. This transition resulted in mixed outcomes for India's education landscape. Factors such as a lack of devices, poor internet quality, and expensive data plans prevented students in under-funded government schools in India from accessing online classes [14]. To circumvent this issue of digital access, teachers and nonprofit workers utilized mass media broadcast technologies like loudspeakers, radio, and TV broadcasts [14]. Interestingly, there was an increase in the use of WhatsApp, a popular social media platform, among teachers. NGOs created groups with teachers to enhance their pedagogical knowledge, organize events to celebrate participating teachers (e.g., with certificates), and foster peer support [40, 71, 72, 74]. These initiatives were successful in reducing teacher absenteeism. WhatsApp groups were also created containing teachers and higher management to streamline school administration. These groups were used to share information with teachers (e.g., announcements and reminders) and provide detailed instructions and resources to aid teachers' work [72]. However, Varanasi et al. [73] found that teachers experienced stress as their personal devices were controlled and repurposed by higher management for surveillance and monitoring of their work, leading to an increase in workload outside of work hours. Further, Dayal [11] also found that a majority of teacher participants experienced physical and mental issues. To manage the stresses due to technology integration and working in isolation, teachers created their own informal support groups through smartphones [21].

Our review of the existing literature revealed a research gap pertaining to teachers' perspectives on the integration of technology across Indian classrooms, encompassing rural and urban settings in both government and private schools. Our work aims to fill this gap by delving into these crucial perspectives, given that teachers are the backbone of the education system. The success of technology integration largely hinges on their adoption and implementation strategies [70]. Furthermore, we also identified a dearth of research studying the impact of NEP 2020 within the education sector, specifically from the teacher's perspective. While existing research offers potential methodologies, a comprehensive evaluation of technology integration in India's education system necessitates diverse viewpoints and primary data. Our study not only addresses these gaps but also introduces a novel dimension by investigating how teachers perceive and adapt to the incorporation of technology in their pedagogical practices. Our primary research goal is to explore the factors influencing Indian school teachers' integration of technology into teaching methodologies, thereby contributing to the existing body of research.

3 Background

3.1 Indian School Education System

India's school education system is the second largest in the world and caters to a staggering 265 million students and employs 9.5 million teachers [69]. Schools in India can be broadly classified into two categories based on their funding source: government and private. Government schools are educational institutions funded and regulated by the state or national government. They

provide free education till elementary school to all children, as mandated by the Right to Education Act 2009 [34], and follow a curriculum designed at either the state or national level. These schools have traditionally been resource-constrained, with students often lacking adequate access to quality teachers and digital resources. Students attending government schools typically come from lower socio-economic backgrounds [46]. In contrast, private schools operate independently of government control or funding. Managed and administered by private entities, these schools primarily rely on student tuition fees for funding. While they adhere to the government-set curriculum, they usually have the means to integrate technology into their teaching methods. Private schools generally cater to students from middle and higher socio-economic backgrounds [46].

Schools in India can choose to affiliate with various educational boards, including the **Central Board of Secondary Education (CBSE)**, Indian Certificate of Secondary Education, International Baccalaureate, and various state boards. This paper focuses on two of these affiliations: CBSE and state boards, as that covers 70% of schools in India [35]. CBSE is a national-level board of education in India and is managed by the Government of India. In addition, each state in India has its own education board, known as the state board, operated by the respective state government. Every state in India has a mix of government and private schools, following the curriculum prescribed by CBSE or their respective state board. CBSE and each state board has resource organizations whose activities include preparing and publishing model textbooks, developing educational kits and multimedia digital materials, organizing teacher training, undertaking and promoting research in school education, and developing and disseminating innovative educational methodologies.

3.2 Education Policies

In the past decade, the Government of India has implemented a significant education policy: the NEP in 2020 [37]. NEP is a comprehensive framework that aims to revamp the Indian education system to meet the current needs and align it with the UN Sustainable Development Goals 2030 with a particular emphasis on quality education. The policy proposes various structural, governance and pedagogical changes, designed to align with technological advancements, the dynamic knowledge landscape, and the country's developmental goals, promoting lifelong learning as a critical element. A key emphasis of the policy is that the *"teacher must be at the center of the fundamental reforms in the education system"*. The policy also acknowledges the bidirectional relationship between technology and education and directs extensive use of technology in teaching and learning, and in professional development of teachers. Furthermore, it proposes substantial investment in a strong, vibrant public education system, and promotes multilingualism in teaching and learning. Focusing on the technology aspect, the policy aims to equip teachers with access to technology, enabling them to incorporate eContent into their teaching methodologies. **DIKSHA (Digital Infrastructure for Knowledge Sharing)** [1] is a platform for providing eContent and facilitating the professional development of teachers. The policy recommends rigorous training for teachers in learner-centric pedagogy and in becoming high-quality online content creators using platforms and tools like VidyaDaan [2]. Initiatives, such as Samagra Shiksha [36] provide grants to states to enhance digital infrastructure, and establish smart classrooms and computer labs in schools. The scheme aims to reach all government schools by 2023-24 [48].

4 Study Design

We conducted a mixed-methods study, which received approval from the **Institutional Review Board (IRB)** at Microsoft Research, India. The study comprised 1,355 survey responses and 20 semi-structured interviews with teachers. Our primary aim was to gain insights into the utilization of technology in the context of Indian education and its reception among teachers.

4.1 Procedure

The study was conducted in India from March to July 2023. Survey participants were recruited through recruitment emails sent via institutional connection, including Vision Empower Trust, and also through personal contacts via WhatsApp. The purpose of the survey was twofold: (1) to gain insight into current teaching methodologies, and (2) to assess the extent and potential of digital technology integration among teachers. To ensure a wide-ranging reach across India, the survey was conducted online using Microsoft Forms and made available in five Indian languages–Hindi, Kannada, Marathi, Tamil, and Telugu–in addition to English. The survey comprised of 34 multiple-choice questions (see Appendix B), and typically took approximately 10 minutes to complete. The survey started with demographic questions around gender, age, highest educational qualification, and years of teaching experience. This was followed by questions related to teaching practices, including the use of technology in instruction, reasons for not incorporating technology, methods of lesson planning, and challenges encountered in teaching. Additionally, we gathered information about the schools where teachers taught, including the type of school (government, private), their affiliation (state board, CBSE), and the available infrastructure. An example of a question from our survey is "*What are the challenges you face while creating lesson plans?*" with options as "a. It's time consuming", "b. I need to identify appropriate resources for references", "c. I need to refer to multiple resources", "d. It's a tedious task", "e. It requires the use of technology", and "f. Other:". We carefully crafted the options to encompass potential responses and allowed participants to make multiple selections. The survey concluded with an optional question inviting participants to provide their contact details if they were interested in participating in a follow-up interview. Survey participants were not compensated for their participation.

Out of the 1,355 survey respondents, a total of 714 teachers expressed interest to participate in the semi-structured interviews. From this pool, a subset of teachers was selected for the interviews using random sampling, with certain constraints in place to ensure diversity in terms of school type (government and private), school affiliation (state board and CBSE), the subject they taught, and their years of teaching experience.

The objective of the interview was to delve deeper into the utilization of technology by school teachers in India. We designed our questions (see Appendix C) to delve into the teachers' workload, their strategies for class preparation, and their approaches for conducting lessons. The aim was to identify where technology is currently improving/hindering their work and to reveal potential areas for further integration. The interviews were conducted virtually via video-conferencing platforms such as Google Meet, Microsoft Teams, and Zoom, based on the participant's preference. To accommodate the linguistic diversity of our participants, we conducted these interviews in four languages: Hindi, Tamil, Kannada, and English. The interviews were conducted by a team of five authors, all proficient in English. One of these authors is multilingual, possessing proficiency in all the languages required for the interviews. Additionally, two members are fluent in Tamil, two in Kannada, and four in Hindi. Thus, no interpreter was needed throughout the process.

Each interview lasted approximately 50 minutes. The interviews were translated and transcribed by two authors proficient in the respective languages to facilitate data analysis. Participants were remunerated with an INR 1000 (~12 USD) Amazon gift voucher for participation.

4.2 Participants

In total, 20 teachers (13 females, 7 males) participated in the interview study. The demographics of the interview participants are available in Table 1, and the demographics of the survey participants are available in Table 2. Among them, 16 were affiliated with state board schools, while the remaining four were associated with CBSE schools. As each state board follows a different curriculum, out of the 16 state board teachers, 6 were from Madhya Pradesh board, 3 each from Uttar Pradesh

Table 1. Demographic Details of the Interview Participants

ID	School Type	Sex	Edu. Board	Exp (yrs.)	Subjects Taught	Grades Taught	State of Residence
P1	Govt.	F	State	10–15	English, EVS, Music, Yoga	6,7,8	Uttar Pradesh
P2	Govt.	F	State	>15	English, Hindi, Kannada, EVS	6,7	Karnataka
P3	Govt.	M	State	>15	Economics	11,12	Madhya Pradesh
P4	Govt.	F	State	>15	Science	11,12	Madhya Pradesh
P5	Govt.	F	State	>15	English, Maths, Science, EVS	5,6,7,8,9	Uttar Pradesh
P6	Pvt.	F	State	5-10	Science	5,6,7	Karnataka
P7	Govt.	M	State	>15	English, Hindi	9,10	Madhya Pradesh
P8	Govt.	F	State	>15	English	9,10,11,12	Madhya Pradesh
P9	Pvt.	F	CBSE	10–15	Science	5,6,7,8,9,10	Delhi
P10	Govt.	M	State	>15	Hindi, English, Maths, Science, Art	3,4,5,6,7,8	Uttar Pradesh
P11	Govt.	M	State	>15	English, Science	9,10	Madhya Pradesh
P12	Govt.	M	State	>15	Science, Maths, EVS, Hindi	8,9,10	Bihar
P13	Govt.	M	CBSE	>15	Hindi	11,12	Punjab
P14	Pvt.	F	CBSE	>15	Sanskrit	6,7,8,9,10	Chhattisgarh
P15	Govt.	F	State	10–15	Science	6,7,8,9,10	Madhya Pradesh
P16	Pvt.	F	CBSE	5–10	Maths	7,8	Himachal Pradesh
P17	Pvt.	F	State	>15	EVS, Economics	1,4,5,11	Tamil Nadu
P18	Govt.	F	State	>15	Science	8	Tamil Nadu
P19	Govt.	M	State	5–10	Hindi, English, Maths, Science	6,7,8	Bihar
P20	Govt.	F	State	10–15	Hindi	6,7,8	Bihar

(**Legend**—Govt.: Government; Pvt.: Private; EVS: Environmental Studies; Edu.: Education).

Table 2. Demographic Details of the Survey Participants ($n = 1,355$)

School Type	Government schools: 1,160	Private schools: 195
Gender	Male: 475, Female: 678, Others: 7	Male: 26, Female: 169, Others: 0
Experience	<5 yrs: 139, 5-10 yrs: 194, 10-15 yrs: 261, >15 yrs: 566	<5 yrs: 35, 5-10 yrs: 46, 10-15 yrs: 37, >15 yrs: 77
Education	School: 52, Bachelors: 253, Masters: 832, Ph.D.: 23	School: 4, Bachelors: 56, Masters: 135, Ph.D.: 0
Edu. Board	State: 971, CBSE: 137, ICSE: 6	State: 118, CBSE: 68, ICSE: 5

and Bihar, and 2 each from Karnataka and Tamil Nadu. Regarding the school type, 5 teachers were from private schools, whereas 15 teachers were from government schools. This distribution aligns with the current ratio of private to government schools in India, which stands at 1:3 [35]. The subject expertise of our teacher participants was diverse, with almost half of the interviewed teachers (9) teaching multiple subjects. This included 9 teachers who taught Science, 8 English, 8 regional languages, 5 Mathematics, 5 **Environmental Studies (EVS)**, 2 Economics, and one teacher each teaching Art, Music, and Yoga. In terms of teaching experience, 13 teachers had over 15 years of experience, four had 10-15 years, and three had 5-10 years. We stopped recruiting more teachers when we achieved saturation in our interview data.

4.3 Data Analysis

Our survey comprised 31 questions (excluding contact details and survey consent), with 10 of these focusing on demographic information and 21 dedicated to exploring teaching practices and processes (see Appendix B). Given that the majority of our questions were multiple-choice, we analyzed the data by calculating the frequency and proportion of responses within different demographic segments to reveal interesting insights. For this quantitative analysis, we utilized the Python Pandas library.

For our qualitative analysis, we employed thematic analysis [10] to identify emerging themes from the interview data. The interview data underwent open coding, and the codes were categorized to comprehend user behavior. Two authors were involved in the coding process, iterating on the codes until a mutual agreement was reached. Throughout the analysis, they discussed coding strategies, developed initial codebooks, reviewed and refined these codebooks, edited codes, and ultimately determined the categories and themes. The initial codes were quite specific, such as "teachers' comfort in using technology" and "teacher forums". After several iterations, these codes were consolidated into overarching themes (See Appendix A, Table 3) like "Role of policy", "Impact of COVID-19 pandemic", and "Influence of Social Media".

5 Findings

The study results revealed three key factors that impacted technology integration in the Indian education system: educational policy, the COVID-19 pandemic, and the influence of social media. Prior to exploring these factors in detail, we present an overview of survey insights that offer an empirical snapshot of the current technology usage, challenges, and effectiveness within India's education sector.

5.1 Overview of Survey Insights

The survey highlighted varying responses across different categories, indicating that the insights may not be fully generalizable across all teachers in India.

5.1.1 Technology Usage. The survey revealed substantial usage of technology in classrooms, with 86.2% of teachers incorporating technological tools. Interestingly, private schools (87.9%) and government schools (86.1%) exhibit similar extent of technology usage. Additionally, YouTube and Google are the leading digital platforms among teachers, with adoption rates of 66.0% and 55.9%, respectively. The DIKSHA portal, particularly endorsed by the government, shows significant use at 47.9% overall, with higher usage in government (61.9%) and government-aided schools (40.0%) than in private schools (22.0%). This reflects the NEP 2020's vision for DIKSHA portal as a primary platform for e-content and teacher development, highlighting the autonomy private schools have in choosing technological platforms.

5.1.2 Challenges and Effectiveness in Technology Utilization. The primary obstacle in adopting technology across all school types and experience levels is inadequate infrastructure, especially in government schools, affecting 66.2% of teachers. Government schools also face more significant difficulties accessing the latest technological advances (27.9%) compared to private schools (17.3%). Teachers with over 15 years of experience often find technology challenging to use or nonessential, with 15.1% reporting usability issues and 14.1% questioning its necessity. Less experienced teachers (<5 years) encounter fewer access-related challenges, suggesting a generational gap in technology usage. Moreover, the effectiveness of technology varies by experience with teachers with 5-10 years of experience have the highest technology adoption rate at 92.8%, likely due to their adaptability and the alignment of their career start with the rise of educational technology. In contrast, those with 10-15 years of experience show a lower adoption rate of 83.1%, indicating a slower adaptation to new teaching tools. This highlights the need for targeted mid-career professional development to enhance technology use. Regional variations are evident, with states like Uttar Pradesh displaying high technology usage (95.6%) and Bihar much lower (71.8%), this could possibly be due to disparities in state education policies, funding, and infrastructure.

5.1.3 Resource Challenges and Benefits of Technology in Teaching. In both government and private schools, a significant majority of teachers rely on school-provided lesson plans (68.1% and

71.7%, respectively). The incorporation of digital platforms is substantial, with 47.7% of government and 46.5% of private school teachers using online resources. Only a small percentage of teachers create their own lesson plans, indicating potential limitations due to time. Experienced teachers (>15 years) face specific challenges in lesson planning, notably in resource identification (44.9%) and technology integration (42.4%). Teachers in the middle of their careers (10-15 years) report similar issues, compounded by the time required (41.4%) to develop effective plans. Challenges also vary by grade level: lower grades (1-5) struggle primarily with finding suitable resources, while higher grades (9-12) contend with technological challenges. In terms of administrative differences, government school teachers predominantly operate in regional languages (36.5%) and bilingual settings (34.0%). This leads them to frequently grapple with identification of appropriate resources (46.3%) and technology usage (42.6%). This could be because finding content that aligns with their vernacular medium is difficult, which complicates the integration of suitable educational resources. Conversely, private school teachers predominantly work in English-medium environments (68.5%), often facing time constraints (45.5%) and the challenge of navigating through an abundant number of resources (45.0%). This abundance requires them to spend considerable time filtering resources to ensure they are appropriate and relevant for their students. These challenges highlight the necessity for targeted strategies to improve resource accessibility and relevance in varying educational settings. Despite these challenges, all teachers recognize the importance of technology for upgrading their own knowledge (75.5%), with government teachers also focusing on lesson planning (49.7%) and classroom delivery (49.4%). In private schools, classroom delivery (56.0%) and customization of teaching content (47.6%) are emphasized, highlighting differing priorities based on the school type and available resources. Next, we present our findings on the three key factors that impacted technology integration.

5.2 Role of Education Policy

The introduction of NEP 2020 brought about a paradigm change in the Indian education system with pedagogical changes and digital integration.

The NEP envisages and enables co-evolution of teaching practices and the technologies to support them. In this section, we analyze the impact of this policy on the integration of technology in the Indian school education system. We discuss its two major implications on technological infrastructure for schools and technology integration in classroom teaching, while reflecting on teachers' perceptions of these efforts.

5.2.1 Building Equitable Tech Infrastructure. Prior research has discussed the issue of inadequate technology resources due to cost constraints and its impact on the accessibility and quality of education, particularly in underserved settings [14, 50, 74].

To counter these technological limitations, NGOs and teachers have made concerted efforts, such as utilizing mobile-based eContent and leveraging tools like WhatsApp [21, 71, 74]. However, these efforts were inadequate. We found that the promotion of technology-mediated education within NEP 2020 has catalyzed the integration of both digital and hardware infrastructure in the Indian education ecosystem, through investments by state and central government, resulting in an increase in technology usage.

NEP has prominently featured DIKSHA [2] as a key enabler in equitable access to educational material. Our survey results highlight DIKSHA as the third most popular resource among teachers, following YouTube and Google Search. Offering curriculum-aligned videos, assessments, teacher training, and lesson plans, DIKSHA was regarded as "*highly influential*" (P10). Concerted efforts were made over recent years to transform DIKSHA into a comprehensive app for teachers. In the interviews, we noted two primary reasons behind DIKSHA's widespread adoption: the trust

placed in its content authenticity, and its easy accessibility via **Energized Textbooks (ETB)** [44]. In P3's words:

> "It [DIKSHA] is an authentic app, it's by NCERT... Even our education department [Ministry of Education, MoE] says that we can take help from this app so I use DIKSHA to put together content." – P3

Additionally, a significant portion of DIKSHA's content has been 'crowdsourced' from teachers across the country, through the Vidya-Daan initiative [1]. Four of our interviewed teachers contributed video lectures to DIKSHA:

> "We were told [by the MoE] to upload some content on the DIKSHA portal. Last year we took five-minute [video] classes and uploaded on DIKSHA. I have created videos for social science." — P2

According to Varanasi et al. [71], technology interventions for teachers often follow a top-down approach, limiting teachers' involvement and potentially acting as a barrier to adoption. In contrast, this participatory approach which is in alignment with NEP's vision of placing teachers at the center of the learning process, has rendered the platform personal and relevant to them.

Besides this, state-level curated online platforms have emerged, offering content catering to teacher's needs, which teachers find immensely valuable. As P4 stated, *"I use DIKSHA portal, Vimarsh, and m-Shiksha Mitra... m-Shiksha Mitra is our Madhya Pradesh government's education portal"*. Furthermore, *'digital libraries'* providing access to diverse eContent have been curated. Another resource we discovered is NISHTHA, provided by the **Ministry of Education (MoE)**, offering online training of teachers and school administrators. These platforms notably provide resources in multiple languages, thereby making eContent more inclusive and accessible for all teachers.

In addition to digital infrastructure, we discovered that recently government grants [35, 36] have endowed schools with smart TV's, smartboards, laptops, tablets, and projectors, which were previously inaccessible in rural and government schools. They have also facilitated Internet connectivity in schools [35]. Despite these efforts, our survey results showed that 'insufficient tech infrastructure' in school to be the topmost challenge faced by teachers in teaching. However, 86.2% of survey participants stated using technology for teaching as a challenge. The interviews revealed that this was largely because even in schools where the technology infrastructure was provided by government departments, they were limited in number thereby were not sufficient for usage by all teachers. P13 reported:

> "The use of a smart board has increased in the last few years but in our school every class is not a smart classroom. We have 2-3 smart classrooms. So weekly one or two classes we conduct in these classes otherwise we follow the traditional method." – P13

We observed that there are several challenges teachers face while incorporating technology in their work. Our survey results indicate that teachers were not aware of the latest technology (19%) and perceived it to be complex to use (18%). While the topmost challenge was their difficulty to source relevant content (23%), we found that the former two could be huge barriers in technology adoption. During the interviews, eight teachers expressed the necessity and the interest to be trained in using technology effectively. In most instances, technology training is offered to only a few teachers selected by the school administrator. Given this context, we observed that teachers viewed the newly provided infrastructure positively, as they believed this would be followed by much-needed technology training conducted by the MoE. This possibility has provided them with greater motivation to learn and include technology in their work.

> "Now we have got directive [from MoE] for ICT [to be used]... labs are being developed by Madhya Pradesh government, in which 10 computers have been provided. Training is yet to be given... as ICT use has to be done in those labs, we will be given training this year." – P3

These diverse efforts to equip teachers with adequate infrastructure and content has increased its accessibility, especially creating more opportunities for teachers from rural and marginalized settings.

5.2.2 Emphasis on Technology Integrated Teaching. Our interviews revealed that NEP has been a key factor encouraging teachers to incorporate technology in their work. Our participant teachers reported that delivery of technology-mediated education was reinforced through NEP teacher-training workshops which emphasized including digital content in their lessons. When asked to reflect on the increase in technology usage in imparting education, a few of them equated literacy with technology literacy, as P2 stated: *"Nowadays, if we don't use technology, we're like educated illiterates"*.

Due to this emphasis, we observed that tech-savvy teachers explored technology to source materials from educational applications and online platforms (e.g., Khan Academy and YouTube), while other teachers depended on the resources recommended by the MoE. We found DIKSHA to be more widely used by the latter category of teachers. This builds on prior work that teachers prefer channels that provide content tailored to their needs and the curriculum [71]. Previously, the language of online content has been a deterrent in its adoption as most resources were available only in English but students learn in a variety of languages [50]. However, NEP's promotion of alternative mediums of instruction has facilitated the creation of digital resources in multiple languages. Teachers valued this access to content in their "*local language*" as it enhances student learning outcomes and teachers were more inclined to incorporate it.

Technology plays a significant role in increasing the 'social capital' of teachers and encouraged them to upgrade their knowledge. Furthermore, it also created new possibilities for teachers and students in underdeveloped districts, through exposure to new tools. For instance, P1 shared:

> "I got the idea of 3D image from social media... Some teacher was doing, then I copied... There are some apps, which allows showing 3D images... like Google Earth is very helpful to teach Geography." – P1

Our analysis revealed various ways in which teachers have adopted the technology integration and their perception of its use and relevance. A few teachers use technology to reduce their effort, e.g., "*If we have to teach brain, then drawing the diagram will take 10 mins, but with technology we can directly show the internal parts of the brain*" (P10). Teachers also found digital content to be useful in reinforcing concepts to students requiring more reinforcement, wherein they could play the content multiple times and address only those concepts that students still found difficult to grasp.

For schools with a lack of educational materials, such as textbooks, 'digital textbooks' provide a valuable alternative. P4, who teaches in a rural school, mentioned *"Sometimes students don't have* [access to] *textbooks, or even we don't get books, then we use the eBook on the... Vimarsh portal"*. Additionally, teachers reported that DIKSHA facilitated student evaluation. P17 shared, "*For commerce class, DIKSHA provides question answering... It is useful for all students whether they are high-level or low-level* [learning level]." Furthermore, 25% of the our survey participants stated that they use technology for designing their lesson plans as well.

While teachers find technology useful, they expressed their discontent with having to search through multiple websites and reviewing multiple resources to find the "*most appropriate content*". It's a demanding task. This was reflected in our survey results as well. Hence, teachers prefer to

use technological resources for concepts they find complex to teach. As pointed out by Gavade et al. [21], it is stressful for teachers to adapt to new pedagogical practices. P6 shared:

> "Sometimes when I want to find an appropriate video or to find a more student-friendly definition for certain vocabulary words, I do have to refer to multiple websites. And it's kind of like a strain on the teacher. Also, it's a waste. I personally feel that teachers spend a lot of time just to prepare even a day's worth of a class. So if there were certified resources available that are student-friendly and also concept-friendly, then the teachers would find it really helpful. It's less time consuming." – P6

Overall, we found that provisions and mandates under the NEP 2020 has contributed to laying the foundations for improved tech infrastructure in schools and enabling teachers to integrate technology in their teaching practices. These are ongoing efforts and technology-related training for teachers would likely be the next area of focus. The enactment of NEP followed the onset of the COVID-19 pandemic in 2020. This timing made NEP's recommendations more significant, as it provided a roadmap to rebuild the education system.

5.3 Impact of COVID-19

Due to the COVID-19 pandemic, educational institutions in India were forced to close from March 2020 onwards. With no clear indication of when the lockdown would be lifted, the MoE had to adapt by transitioning to eLearning platforms. This sudden shift led to multiple outcomes that influenced the use of technology in Indian education. The rapid transition from in-person to online classes significantly affected a vital stakeholder of the education system: the teachers. Below, we analyze the substantial impact of COVID-19 on the integration of technology within the Indian education system. We delve into its implications for teachers, their response to this evolving landscape, and the current state of technology adoption within the educational context.

5.3.1 Expediting the Use of Technology in Indian Education. To facilitate transitioning to online classes, the MoE provided formal training to teachers through webinars about the development and distribution of digital content, and using applications such as Google, YouTube, and video-conferencing tools like Google Meet, Microsoft Teams, and Zoom [43].

> "Two years ago we were trained to use technology on a mobile and were asked to teach students as well. We teachers were trained first, as 5 years ago we never did any online classes... Training sessions were across 2-3 days and the sessions were 1 hour each. We were taught how to use Google Meet and Webex and something else as well. We were taught how to get students on call, etc." – P15

The MoE also provided access to training videos and eContent on platforms like DIKSHA and VidyaDaan [43], and encouraged their use in virtual classrooms to engage students [61]. The majority of teachers in government schools had little to no prior experience with the usage of technology in educational contexts before the pandemic. For example, P2 elaborated on the physical artifacts used for teaching before COVID-19.

> "Pre-COVID there was no technology in the classroom, there was no video audio, it was just manual. It was interaction between teachers and students only. We used to create flashcards, charts, we used blackboard heavily... charts were being used, mainly for science and maths... whatever we could get from bookstores. We didn't use videos." – P2

Additionally, P2 and P3 reported that they acquired their technological skills only in response to the pandemic. On the other hand, most private school teachers had access to Internet and digital

devices, and were aware about online resources such as OLabs[1] to conduct informative classes in addition to more widely adapted platforms like DIKSHA.

> "During COVID, we have got the virtual lab also, we can show everything on the Internet. Virtual Lab app is there. It is OLab I think. So actually we have everything. They have every equipment you can pick it up, you can pour it and you can do titration also... you can do dissection and everything, that was a very good app that we were using." – P9

However, both government and private school teachers had a learning curve switching to eLearning. P9 mentioned *"I think there are many technology methods which we are not aware of. Somebody tells us, then we go and search it and then we do it."*. P17 stated that she took help from her children to make presentations for her students during COVID-19. In addition to conducting online classes, teachers formed WhatsApp groups organized by district and subject to facilitate discussions among themselves regarding content, problems, and ideas. Furthermore, teachers created WhatsApp groups with parents to share resources such as YouTube videos, worksheets, and notes for their children.

> "During that [pandemic] time we did not have chalk duster, so we used to... click photos of the lesson and share it with the students. Then we used to read those photos and teach them on the images... Sometimes we used to share YouTube videos in the WhatsApp group to teach the students." – P4

Two of our teacher participants also mentioned how these resources were particularly beneficial for students with working parents who did not have access to a smartphone during the day to attend online classes, "*At night between 8-9 pm, I put questions on WhatsApp group for children. All parents give their phones to their kids at that time.*" (P19).

In response to the difficulties rural students faced in accessing digital devices to participate in online classes [51], teachers initiated 'mohalla classes'. Specifically, P10 said, *"during the pandemic we used to conduct 'mohalla classes' in between online classes. This was used a lot and student learning level was maintained*". In these classes, one student with a smartphone would sit in a common area with 6-7 other students who did not have access to one. This approach ensured that such students received at least some level of education. Conversely, students in government schools situated in urban areas generally had access to smartphones [26], but our teacher participants stated that some were misusing this privilege. For example, P2 stated,

> "As much as technology is useful for us it has its demerits. Students are always using mobile and they are not using mobile in a positive way. They trick their parents and tell them that the teacher has given work on the mobile... and take the mobile from the parents and waste their time on mobile." – P2

This is an example of how different environments and locations plays a significant role in the way technology is used and the challenges teachers faced during the lockdown.

Furthermore, our private school teacher participants mentioned challenges while conducting online classes such as determining student engagement and comprehension.

> "If I'm taking an online class, for me, the challenge is that I write on the board, but how do I assess what the student is doing? That is the main thing... I have the pen and I write on the board and I share the screen. If I want that child to give me the answer and if I want him to write on the same board where I'm writing. That is the challenge... We can't assess the students when we are teaching online." – P9

[1] http://www.olabs.edu.in/

From this, it can be inferred that teachers had difficulty adjusting to the "new normal". Prior work has mentioned this challenge and suggests that a virtual face-to-face interaction between participants and hosts is crucial for successful two-way dialogue in online classes. This fosters a classroom-like environment, promotes attentiveness, enables teachers to better assess class needs, and enhances interactivity [61]. In conclusion, the pandemic catalyzed a transformative shift in educational practices, with teachers adapting to meet the diverse needs of their students. Notably, we observed that government school teachers focused on ensuring access for their students, while their counterparts in private schools emphasized student comprehension and engagement in online learning. There has been a significant surge in technology adoption for teaching in both government and private schools as a direct response to COVID-19.

5.3.2 Exploring the post-COVID State of Technology Integration in Schools. The rapid adaption of technology due to COVID-19 has had lasting positive effects that are being witnessed even after the pandemic is over. As previously discussed in Section 5.2.1, infrastructure such as smart TVs and Internet connection were provided to government schools. Educational content were preloaded on the smart TVs or provided via USB drives by the MoE and EdTech organisations. Teachers stated this content to be pivotal in transforming classroom delivery. We observed that this had brought about a change in teachers' perception of their work. They expressed that their role is transitioning to that of a "*facilitator*" in the learning process, as they found the eContent to be very well-aligned with the curriculum. P2 felt that she could effectively run a "*teacher-less classroom*":

> "The SmartBoard have videos, grammar points, question and answers, notes and everything available on it. Sometimes when we are not in classroom, if we switch on the TV and go, the students themselves can learn from it. For science and maths, the SmartBoard is extremely useful..." – P2

Another interesting use case shared by a school administrator was that it helped them address the issue of teacher shortage, which is quite common in India [66]. He stated that digital content helped him engage students from multiple classes at the same time, during teacher shortage or absenteeism. Additionally, we found that P13, a Hindi teacher, used smart TVs to supplement the educational syllabus with background information and context on the authors and poets. These examples demonstrate the diverse ways in which smart TVs were leveraged to meet a variety of educational needs. However, using them presented logistical challenges, as it required the entire classroom to relocate to a designated room. Several teachers expressed the need for having multiple digital devices in their schools to overcome this issue.

In contrast, private schools had access to digital resources like smart TVs prior to the pandemic. They additionally started using various services like CampusPro and Edusecure[2] to make their administrative tasks and teaching processes more streamlined. For example, P14, a Sanskrit teacher, explains how they provide questions online to students and request that they submit written hard copies of their answers.

> "Actually, it's because we want our children to practice writing for the board exams. So, we do give our students the questions online. Also if we get these printed, we waste a lot of paper... So now we upload the questions in Campus Pro and get them to bring in the written answers." - P14

We also inferred from P14's interview that this could be to reduce the workload of teachers. For languages such as Sanskrit and Hindi, teachers are required to write question papers by hand and then type them. Typing in Devanagari script presents a steep learning curve and can be time

[2] https://campuspro.in/index.aspx and https://edusecure.in/

consuming. This highlights the challenges faced in a diverse country like India with numerous native languages and dialects. Even with the use of script specific keyboards and Google translate, creating and sourcing context-appropriate content for students is a laborious task.

In addition to delivering content using technology, many teachers started to search for information online, rather than relying solely on books, to enhance their understanding of various subjects. This is also evident from our survey which indicated that 75.5% of teachers believe that technology can benefit them in upgrading their knowledge. Interestingly, P12 even used Google during his classes to verify information and improve his teaching.

> "Like previously, we used to take help of dictionaries to know the meaning of new words, but now no school has a dictionary. Everybody just uses their smartphones and Google whatever they want to learn about. Since smartphones have come, no teacher has kept any "refresher" books with them. When we are stuck with something in a class, we go outside for 2 minutes to Google for solutions.; - P12

Overall, our findings indicate that teachers are welcoming technology with enthusiasm. For example, P13 emphasised the importance of combining traditional teaching methods and technology to offer students a fresh way of learning.

> "Traditional method and new technology, both are important. In traditional method we are individually taking efforts for it. But like I spoke about digital libraries and e-books, I will teach children one book but if I am able to provide them knowledge through digital libraries and e-books, I will give them a new world. From here they can learn a lot of different things... If we are aware about all these [digital libraries] then we can provide them with these. For this technology is very important." - P13

Also, P13 expressed how technology could be used to perform "*smart work*" to increase productivity. This highlights that exposure to technology has opened new opportunities for teachers to explore and enhance their teaching methods.

5.4 Influence of Social Media

The rapid growth in the usage of technology in India has contributed to increased student exposure to social media platforms [15]. In Sections 5.2 and 5.3, we discussed how WhatsApp facilitated the sharing of information with students, the exchange of innovative ideas among teachers, and the distribution of assignments, thereby enhancing the overall teaching and learning experience. We further discuss the role of social media platforms in imparting education.

5.4.1 WhatsApp (Social Communication and Sharing). WhatsApp has become a widely used platform in India with its user base reaching approximately 493.31 million users as of 2021 [12]. It has proven to be an efficient medium for staying connected and disseminating information. It has transcended barriers of age and technological proficiency, becoming an accessible technology for individuals from various backgrounds [75]. In the realm of education, teachers, even those with minimal technological experience, mentioned WhatsApp to be a convenient and user-friendly tool.

> "WhatsApp is used by 95% people. There are very few people who use a feature phone. There are few teachers who don't want to learn [technology]." – P19

We found teachers using WhatsApp groups to maintain connections with other teachers across their respective states, which helped them to draw and provide inspiration. P1 mentioned existence of various state-level WhatsApp and Facebook groups where innovative ideas gets exchanged and subsequently implemented in their teaching methodologies.

> "We have state level WhatsApp group of teachers in which we share... If I do something innovative in my school then I share on the group, whoever likes it will copy it. I also

> take from other teachers good work... whatever is good, can be taught in a unique way... I copy it in my school." - P1

Interestingly, P19, a teacher from Bihar (a state in eastern India) mentioned that he has a few teacher friends in Uttar Pradesh (a state in northern India) with whom he shares and receives content from. This emphasises that WhatsApp has facilitated connections between teachers beyond their respective state borders to share valuable content and teaching techniques. Previously, teachers primarily interacted and exchanged ideas with other teachers within their own state.

Our interviews revealed that both private and government school teachers encountered no challenges in using WhatsApp during COVID-19. Apart from teachers group, WhatsApp group of students and teacher were being leveraged to share logistical information with students after school hours.

> "We have separate WhatsApp groups for class 6, 7, 8 and the students of each of those classes are in it, their guardians, teachers, etc. To give some information, for example, yesterday we had to suddenly go to school to celebrate yoga day, so we messaged in the group that students should reach school at this time." – P1

In contrast, some teachers expressed challenges with such students-teacher groups. This shift in attitude was because the students and parents contacted these teachers at inappropriate hours and disregarded instructions delivered during class. For instance, P9 recounted instances of students calling her after work hours to request explanations for specific tasks.

> "Students video call me at 11 o'clock in the night saying that I don't understand this please explain. So sometimes it's very awkward... even if it's a simple call, after some time a person should not call but the students just call. As soon as the holidays are about to be over, the students will start calling. How to do this, what to do, on which paper, etc." - P9

She also mentioned that parents and students gave greater importance to instructions disseminated over WhatsApp, as opposed to those delivered during class or posted on the official school website. Private schools generally have their own web portals or phone applications to communicate with students and parents beyond school hours [45]. In contrast, as government school teachers do not have access to these platforms, they are reliant on and comfortable using WhatsApp for the same purpose.

5.4.2 Students Awareness and Demand. Our findings suggest that in addition to usage of WhatsApp, the penetration of Internet, particularly in rural India [52, 76], has transformed the student-teacher dynamic and facilitated the incorporation of technology in teaching. Akin to market dynamics, while provisions in the NEP framework creates a 'Nudge'[3] for technology integration in education, we found that students' exposure, aspirations, demands and socio-economic backgrounds have also created a 'Pull'[4] for teachers to explore multimedia resources.

The growing student exposure to global content has prompted teachers to explore and experiment with technology, enhancing learning and development of both teachers and students. This finding is building on prior work, which reported the use of social media for occupational skilling by teachers [24]. Teachers stated that they watched videos on academic websites (e.g., Khan Academy) to learn how to teach specific concepts and to cater to the learning preferences of their students. However, it was interesting to find that students were often the first to learn the latest technological developments and actively disseminate this to their teachers. Three teachers in our

[3]The 'Nudge' policy theory as defined by Richard Thaler and Cass Sunstein is 'any aspect of choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives'.
[4]A marketing strategy which organically 'draws' users to products/applications.

study mentioned that they learnt about 'ChatGPT' from their students. P2 attributes many new learnings to her students:

> "Students are much more clever in using mobiles than their parents. There are so many things that we don't know and students teach [us] those things... They say ma'am go [click] here, search over here... If there is any new app which needs to be downloaded, they only suggest [it to me]" - P2

We observed that this *information asymmetry* has also led teachers to prioritize students' inputs. The results of our survey reveal that 'Student participation/response' is the foremost criterion teachers use to evaluate the efficacy of their lesson plans, followed by student 'learning outcomes' and 'exam scores'. Furthermore, during the interviews, teachers stated that they solicit feedback from students and it plays a crucial role in designing lesson plans. P5, who teaches in a rural school, remarked that students, irrespective of rural or urban areas, *"lack interest in learning using the old technology [traditional teaching methods]"*. This has motivated teachers to adopt interactive multimedia tools such as virtual labs and digital libraries, gamification of concepts as well as audio-visual aids, to enhance the learning experience of students.

However, many teachers expressed their difficulty in 'learning on the go' when it comes to these technology tools. According to our survey, the foremost challenge while creating lesson plans was 'identifying appropriate resources' (44.6%), followed by the 'difficulty in using technology' (41.1%). P9 shared that she is struggling to keep up with the rapid growth in technology and was unaware of many "*new tools*" which might be useful:

> "That is what the challenge is...that we have to find [content] every time, we have to work for something new because students get bored... so we [teachers] have to find out new methods, how we can make classes interesting... You see something and then it clicks [in our mind], this activity I can use there [in the lesson]." - P9

Furthermore, teachers expressed their disapproval of the wide use of technology by students. P12 estimated that only 20% of students use it productively while 80% misuse it. Teachers also shared their doubts about the suitability of the content students access and how its monitoring has added to their workload. Despite the challenges, it was evident from our interactions that students' growing awareness will continue to increase the use of technology by teachers.

5.4.3 Social Media Influences and Influencers. The Internet has significantly impacted the nature and medium of content consumption among students. Teachers reported that incorporating content from popular social media platforms, such as YouTube, Facebook, Instagram, and so on, into their lesson plans makes it more "*attractive*" for their students. Teachers have adapted to the time students spend on social media by using it as a medium to facilitate learning. Not surprisingly, four teachers mentioned creating their own YouTube channels and have become 'social media influencers' in their own right. In an effort to connect with these "*digital natives*", they use it as a medium to share motivational and entertaining material, apart from educational content.

Other teachers have novel motivations for foraying into social media. P3, a teacher in a rural girls school, started creating YouTube videos with minimal equipment to tackle various challenges such as studying at home, and absenteeism and dropouts among girls. He believed that students would be more motivated to continue studying at home if they could watch their own teacher in the video:

> "I made motivational video on YouTube and uploaded that to motivate students... for example, 'how to study while staying at home', 'how to prepare for competitive exams from home'... This type of video I share and many students have watched it. I have

> almost 5,000 subscribers on YouTube and many students watch who are not from our school as well." - P3

We observed that this also facilitates the production of hyperlocal content, as many teachers rely on videos created by other teachers in their state as a reference for context-specific and relatable content. P18 shared that she finds content that is appreciated by her students through these mediums:

> "There is a lot which can be shown for Tamil. I can only teach a lesson through words but in YouTube, someone would have sung it as a song. The students will find that more interesting. I don't know how to sing, [but] someone else would... I use videos like street plays [to make concepts engaging]" – P18

This has also fostered a healthy competition among teachers to innovate and have their methodologies adopted by other teachers. In addition, we found that some states have initiatives to encourage this spirit through various competitions. However, P13 suggested that while teachers need to be aware of students' preferences and it would help them supplement the traditional method of teaching, it can be a source of distraction and hence students also require guidance on the content. He stated:

> "The new generation is very fond of YouTube [shorts], reels, etc., as teachers we have to show them the world that is actually made for them and is important for them like digital libraries. If we are aware about all these then we can provide them with other tools." – P13

Our findings suggest that with the rapid growth in Internet accessibility and social media exposure, its influence on the education ecosystem will inevitably grow stronger. It has the potential to revolutionize the teaching-learning process and pave way for novel approaches such as *flipped classrooms*[5] becoming the norm in India.

6 Discussion

Below, we reflect on our findings that revolve around the themes of teacher agency and technology adoption. These findings encapsulate various dimensions: the multifaceted ways in which teachers perceive technology, their innovative strategies to address issues such as teacher shortages through the integration of technology, the challenges they encounter due to insufficient technology training, and their transformation into content creators amidst a lack of culturally relevant material. These insights provide valuable recommendations for researchers, policymakers, and practitioners working in the education sector.

6.1 Equitable Opportunities for Teachers

Our findings show how the NEP 2020 has created equal opportunities for teachers across the urban-rural education ecosystem, through access to technological infrastructure and promoting technology mediated teaching. To put it in perspective, it is crucial to understand that rural areas account for over 83% of the total schools in India [35]. Technology and digital resources have long been inaccessible to most of them. We found that the thrust for technology integration has revitalized and revolutionized teaching practices, with many of them being developed organically by the teachers themselves. This has accorded greater agency to teachers in teaching as well as their professional development. Content on platforms such as DIKSHA have also been crowdsourced from teachers. While social media has been used for learning and skilling [24], we found teachers adapting to its

[5]A flipped classroom is an instructional strategy which aims to increase student engagement by having students watch videos/online classes/complete readings at home and work on problem-solving/discussions in the classroom.

latest trends to reinvent their teaching practices as well as their role in the education process. This is reflected in how teachers in rural schools have started their own YouTube channels.

Access to technology and push for integration of technology when supported by policy has the potential to facilitate the latest technologies such as LLMs to reach diverse and marginalized user base and build inclusive systems. Teachers, especially from rural India, want to teach students content in local context when the textbooks largely focused on national and global level content. Previous work has discussed the importance of aligning technology with teachers' pedagogical beliefs and the context of the classroom, for successful adoption. It suggests 'co-teaching' as a form of design practice [41]. We believe technologies such as LLMs can also be leveraged for this and provide personalized support to teachers, as well as enhance their content and pedagogical knowledge. As teachers now take the centre stage in the efforts to transform education in India, we believe this opens up the opportunity for them to not only benefit from such latest technological developments, but also make them co-creators of tech solutions for the sector.

6.2 Varied Extent of Technology Used: What is the Right Amount?

As one of our teachers pointed out, the future of education lies in a balanced blend of traditional and technological methods (similar to [63, 65, 70]), tailored to the needs and interests of students.

In our study, we observed various approaches that blended technology and traditional teaching. Teachers regarded digital content as a means to streamline manual tasks.

For instance, instead of laboriously drawing diagrams on the board, they believe projecting images will enable more efficient and time-effective explanations. Some teachers viewed the integration of technology as a means to multitask, helping them to deliver content while simultaneously attending to administrative duties, thereby optimizing their time. Conversely, teachers considered technology as a valuable 'substitute teacher', particularly when facing staff shortages. Although presence of teacher physically in classroom is crucial in early education [4], using technology to manage teacher absence has its own merits. It engages students with digital content, which is more beneficial than idle time in the absence of a teacher. Given the steady rise in the integration of digital infrastructure in schools and the incorporation of smart devices such as Amazon's Alexa into classrooms, it could enhance children's engagement with the content. Instead of passively consuming information, students could actively participate in interactive question-and-answer sessions, making learning a more dynamic and engaging process. Lastly, it is important to recognize that there's no one-size-fits-all approach to technology integration in education. The extent to which technology should be used varies based on factors such as teacher availability, student age, subject matter, class duration, and topic complexity.

6.3 Need for Comprehensive Technology Integration

The COVID-19 pandemic has catalyzed a significant transformation in the incorporation of technology within the Indian educational system, a shift that might not have been feasible at such a rapid pace under normal circumstances. Our research indicates that the pandemic impacted the way Indian teachers embraced blending traditional pedagogy with technology-enabled approaches. Moreover, post-pandemic, the NEP 2020 played a significant role in sustaining the COVID-19 impact. We also observed drastic changes in teaching methodologies, especially in low-resource schools where teachers transitioned from sparse use of technology to employing smart boards in their classrooms post-pandemic. However, this transition is not devoid of challenges. Teachers seem to have a complex relationship with technology. They acknowledge its potential in facilitating the teaching of intricate concepts and in engaging students, yet they grapple with its integration into their daily teaching routines. This struggle is intensified by a lack of technological training and infrastructure.

To ensure the successful integration of technology in education post-pandemic, it is crucial for the government to implement NEP [37] which mentions providing technological infrastructure to schools and technology training to teachers.

Our research showed that integration of technological infrastructure is steadily progressing whereas technology training of teachers for the same is still lagging. Previous work has offered teachers an array of resources, such as video content [6, 33, 54], audio content [19], and text messaging [27] to help with training. However, it remains uncertain whether merely providing these resources is sufficient to support teachers in implementing innovative pedagogical programs [25] that incorporate technology.

The technology training provided to the teachers should be comprehensive, engaging, and not perceived as a burdensome task [33]. Moreover, it is important for teachers to have a clear understanding of their training progress. There are certain initiatives taken by the government such as NISHTHA that track teacher training but fall short in providing this information back to the teachers. Similarly, despite DIKSHA's capabilities, it is not used by all Indian teachers. We believe these suggestions and initiatives will support reaching all teachers, especially those in low-resource schools with minimal exposure to technology compared to their urban counterparts. This will empower them to leverage technology to enhance their teaching methodologies while addressing the challenges posed by this transition.

6.4 Limitations

We acknowledge several limitations of this work. First, resource constraints restricted us from conducting on-field research, necessitating that participants have some level of access to technology to participate in the study. Second, due to the diversity of the sample, the findings of the study may not be generalizable to all teachers in India. Furthermore, our study primarily focused on the experiences of Indian educators, suggesting that the applicability of our findings may not extend beyond the Global South. Third, the study was conducted in languages familiar to the researchers, which may have excluded potential participants who were not proficient in these languages.

7 Conclusion

In this paper, we delve into India's evolving educational landscape, where the push for a 'digital-first' economy aligns with the pursuit of inclusive education. As India progresses towards inclusive, technology-driven education, understanding teachers' experiences becomes paramount, given their central role in this digital revolution. We conclude by discussing how factors such as the COVID-19 pandemic, the NEP 2020, and the influence of social media contribute to fostering equitable opportunities for teachers from diverse backgrounds to integrate technology into education. Our research underscores the resilience and creativity of teachers in overcoming resource limitations. In essence, these factors are paving the way for more equitable technology integration in education, which holds immense promise for the future.

Appendices

A Codebook from Qualitative Analysis from Interview Data

Table 3. The Codebook that Resulted from Our Analysis of Qualitative Interviews, Showing Three Themes (Bold) and 18 Codes, Including the Total Count for Each Theme/Code

Theme/Code	Count
Role of Education Policy	**327**
Education department resources	112
Different government schemes	27
Infrastructure	68
Classroom teaching	64
Teacher training	56
Impact of COVID-19	**495**
Teacher's comfort using technology	143
Resources used	145
Beyond school connect with students	14
Teachers' dedication and extra efforts	58
Availability of technology	49
Teaching learning material	34
Student background	52
Influence of Social Media	**141**
Teacher forums	22
Parent teacher contact	13
Content assessment	14
Lesson plan structure	41
Student's comfort using technology	39
Knowledge upgradation	12

B Survey Questions

Q1. Do you consent to participate in this study?
Option 1: Yes; **Option 2:** No

General Information

Q2. What is your gender?
Option 1: Woman; **Option 2:** Man; **Option 3:** Non-binary/gender diverse; **Option 4:** Self Described; **Option 5:** Prefer not to say

Q3. What is your highest qualification?
Option 1: Grade 12; **Option 2:** Bachelors; **Option 3:** Masters; **Option 4:** M.Phil; **Option 5:** PhD

Q4. Do you hold a BEd degree?
Option 1: Yes; **Option 2:** No

Q5. How many years of teaching experience do you have?
Option 1: < 5 years; **Option 2:** 5-10 years; **Option 3:** 10-15 years; **Option 4:** >15 years

Q6. You are a teacher in a:

Option 1: Government school; **Option 2:** Private school; **Option 3:** Government-aided school

Q7. Which education board is your school affiliated to?
Option 1: CBSE; **Option 2:** ICSE; **Option 3:** State

Q8. Which State Board is your school affiliated to?
Option 1: Andhra Pradesh; **Option 2:** Arunachal Pradesh; **Option 3:** Assam; **Option 4:** Bihar; **Option 5:** Chhattisgarh; **Option 6:** Goa; **Option 7:** Gujarat; **Option 8:** Haryana; **Option 9:** Himachal Pradesh; **Option 10:** Jharkhand; **Option 11:** Karnataka; **Option 12:** Kerala; **Option 13:** Madhya Pradesh; **Option 14:** Maharashtra; **Option 15:** Manipur; **Option 16:** Meghalaya; **Option 17:** Mizoram; **Option 18:** Nagaland; **Option 19:** Odisha; **Option 20:** Punjab; **Option 21:** Rajasthan; **Option 22:** Sikkim; **Option 23:** Tamil Nadu; **Option 24:** Telangana; **Option 25:** Tripura; **Option 26:** Uttar Pradesh; **Option 27:** Uttarakhand; **Option 28:** West Bengal; **Option 29:** Andaman and Nicobar Islands; **Option 30:** Chandigarh; **Option 31:** Dadra and Nagar Haveli and Daman & Diu; **Option 32:** Delhi; **Option 33:** Jammu & Kashmir; **Option 34:** Ladakh; **Option 35:** Lakshadweep; **Option 36:** Puducherry

Q9. Which subjects do you teach? (You can choose multiple options)
Option 1: Hindi; **Option 2:** English; **Option 3:** Mathematics; **Option 4:** Science; **Option 5:** Environmental Studies; **Option 6:** Art; **Option 7:** Music; **Option 8:** Regional language; **Option 9:** Other

Q10. Which language do you teach in?
Option 1: English; **Option 2:** Regional Language; **Option 3:** Mix of English and regional language

Q11. Which grades do you teach? (You can choose multiple options)
Option 1: Below Grade 1; **Option 2:** Grade 1; **Option 3:** Grade 2; **Option 4:** Grade 3; **Option 5:** Grade 4; **Option 6:** Grade 5; **Option 7:** Grade 6; **Option 8:** Grade 7; **Option 9:** Grade 8; **Option 10:** Grade 9; **Option 11:** Grade 10; **Option 12:** Grade 11; **Option 13:** Grade 12

Q12. What is the average number of students in your class?
Option 1: <10; **Option 2:** 10 - 20; **Option 3:** 20 - 30; **Option 4:** 30 - 40; **Option 5:** 40 - 50; **Option 6:** > 50

Overview

Q13. What are some of the challenges you currently face in teaching? (you can choose multiple options)
Option 1: Lack of learning aids for students; **Option 2:** Insufficient teaching resources (E.g., physical teaching resources, digital aids, etc.); **Option 3:** Creating lesson/teaching plans; **Option 4:** Updating teaching skills; **Option 5:** Insufficient infrastructure in school (E.g., Internet, classroom projector etc); **Option 6:** Student Assessment; **Option 7:** Other

Q14. Rank the below options (by moving the boxes) based on how much time you spend on each (1 being the highest and 6 being the lowest)
Preparing for teaching the concepts (self-study); Creating lesson/teaching plan; Student assessment; Administrative work; Teacher Training; Teaching

Teaching Practices: Class Preparation

Q15. How do you prepare for your classes?
Option 1: I create a plan at the beginning of the academic year; **Option 2:** I decide what to teach on a monthly basis; **Option 3:** I decide what to teach weekly; **Option 4:** I create plans for every session based on the previous one

Q16. Do you create your own teaching/lesson plans from scratch?
Option 1: Yes; **Option 2:** No

Q17. Which of the following resources do you use for your teaching/lesson plans?
Option 1: Plans provided by my school; **Option 2:** Online resources; **Option 3:** Diksha portal; **Option 4:** Other

Q18. What are the challenges you face while creating lesson plans? (you can choose multiple options)
Option 1: It's time consuming; **Option 2:** I need to identify appropriate resources for reference; **Option 3:** I need to refer to multiple resources; **Option 4:** It's a tedious task; **Option 5:** It requires use of technology; **Option 6:** Other

Q19. On average, how much time do you spend preparing a lesson plan for a single class?
Option 1: <1 hour; **Option 2:** 2 hours; **Option 3:** > 2 hours

Q20. How do you gauge the effectiveness of your lesson plan? (you can choose multiple options)
Option 1: Student participation/ responses; **Option 2:** Learning outcomes; **Option 3:** Student exam scores; **Option 4:** Completion of required academic syllabus

Teaching Practices: Personalization of Content

Q21. Do you customize teaching content for your students?
Option 1: Yes; **Option 2:** No

Q22. Which of the below ways do you adopt? (you can choose multiple options)
Option 1: Make the content personal to each child; **Option 2:** Make it relevant in the local context; **Option 3:** Make use of visual aids; **Option 4:** Other

Q23. How much do you rely on technology for this customization?
Not at all; Little; To some extent; To a high extent; Completely

Q24. If no, what are the reasons you don't customize? (you can choose multiple options)
Option 1: I don't think it makes a big difference in students' learning outcome; **Option 2:** I'm interested in doing it but I don't have the time to prepare; **Option 3:** I won't have time to complete the given syllabus; **Option 4:** Other

Teaching Practices: Classroom Technology

Q25. Do you use technology for teaching?
Option 1: Yes; **Option 2:** No

Q26. If not, why?
Option 1: I don't find it simple/easy to use; **Option 2:** I don't feel it is mandatory for students' learning; **Option 3:** It is time consuming; **Option 4:** Lack of infrastructure in school; **Option 5:** I don't have access to the latest technology; **Option 6:** Other

Q27. In the last week how often have you used technology for teaching?
Option 1: Very frequently; **Option 2:** Regularly; **Option 3:** Occasionally; **Option 4:**

Q28. Which of the below resources do you use for teaching? (you can choose multiple options)
Option 1: YouTube; **Option 2:** Bing Chat; **Option 3:** Diksha portal; **Option 4:** I don't find relevant content quickly; **Option 5:** Academic websites (E.g., Khan Academy); **Option 6:** Google; **Option 7:** Other

Q29. What are the challenges you face while using technology for teaching? (you can choose multiple options)

Option 1: I don't find it simple/easy to use; **Option 2:** I'm not aware of the latest applications; **Option 3:** I don't know how to use latest technology for my work; **Option 4:** I don't find relevant content quickly; **Option 5:** I don't have access to latest technology; **Option 6:** None; **Option 7:** Other

Q30. What are the infrastructural resources available in your classroom? (you can choose multiple options)
Option 1: Projector with screen; **Option 2:** Internet connectivity; **Option 3:** Tablet devices for students; **Option 4:** Hands-on kits for students; **Option 5:** Teaching aids; **Option 6:** Relevant books and reading materials; **Option 7:** Other

Q31. Beyond textbooks, what are the approaches you adopt while teaching for better understanding of concepts? (you can choose multiple options)
Option 1: Audio-visual aids; **Option 2:** Hands-on learning; **Option 3:** Play-based learning

Q32. Which of these areas do you feel can benefit from the use of technology? (you can choose multiple options)
Option 1: Upgrading my knowledge for better teaching; **Option 2:** Classroom delivery; **Option 3:** Teacher training; **Option 4:** Customizing/personalizing teaching content; **Option 5:** Creating lesson/teaching plans; **Option 6:** Other

Contact Details

Q33. Kindly share your contact details IF:
Option 1: you want to be considered for the interview; **Option 2:** No, I am not interested in participating in the interview

Q34. Name

Q35. Mobile Number

C Interview Questions

C.1 Icebreakers

Thanks for participating in the study. I understand that you have been teaching in a *government* school for X years and you teach *these* grades *these* subjects.

(1) What do you enjoy most about teaching?
(2) Which grades do you like teaching most? Which grades do you like least, why? Which grades need more assistance or work to prepare for?
(3) What subjects do you like to teach? Why?
(4) What is your teaching load? How many periods do you take each week?
(5) What does your weekly timetable look like?
(6) Do you have pressure from school to improve the pass percentage? In which grades do you have such pressure?
(7) This study is about technology use by teachers.
(8) Can you tell me how you use technology today/ what do you use?
(9) When do you use it?

C.2 Broad Questions

(1) How do you prepare for a class? For example, you are preparing to introduce/start a lesson *name*.
   (a) Do you personalise content for your classes? How?

(b) How do you prepare and teach so many classes? (For teachers who teach 4-5 periods each day, can refer to the answer given for the rapport-building question)
(c) How much time does it take for you to prepare for each class?
(d) Do you use technology? How? Does it benefit you?
(e) How do you identify resources for preparation?

(2) If you had to teach *topic name* in class today, how would you go about it?
(a) Do you use play-based teaching methods?
(b) How do you make the class engaging?
(c) There are few students who are excellent and few who have difficulties. What approach do you take to teach such a mixed group? - Do you have time to assist the struggling students separately?
(d) How do you help students to prepare for exams?
(e) Do you use technology to assist you during teaching? Example: videos or presentations to teach the concepts?

(3) Do you have the time to improve your own knowledge? How do you manage to keep yourself well prepared?
(a) Does technology play a role in it? If yes how? What technology do you use?
(b) Do you have teacher training? Is technology a part of it? Have you found it useful?
(c) What do you think can make teaching more effective and less stressful?
(i) How can technology play a role?

(4) What would be helpful for you to improve student learning and performance?
(5) Where do you think technology can help you?

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