EdTech for India

LEVERAGING TECHNOLOGY
TO BRIDGE LEARNING GAPS

CENTRAL SQUARE
FOUNDATION

EdTech for India: Leveraging technology to bridge learning gaps

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Content

Foreword

Existing challenges in the education ecosystem, exacerbated by the COVID-19 pandemic, have led to immense and varying levels of learning loss across the country. One of the ways in which this loss can be mitigated and learning recovery can be supported is by leveraging digital resources to supplement the educational process. In a J-PAL review of nearly all of the 40 studies, which compared students using adaptive software with peers who were taught by conventional means, the software-assisted students received higher scores.

While it remains clear that nothing can replace the teacher and the school, it is promising to see technologies like personalized adaptive learning and gamification being used by the Indian government and other players, both during and after the pandemic. The key to ensure that technology can effectively support the school system is robust procurement, capacity building for deployment, and rigorous monitoring and evaluation. A coordinated approach between the Union and State governments will be important to ensure that the implementation of digital intervention is robust, focused and impactful.

The power of EdTech is in its ability to generate invaluable data. Apart from the data that the products capture, there will be gradual accumulation of publicly-sourced questions, student responses, and remediation content. A repository like this, if curated, anonymized and made publicly available, can have enormous positive externalities. For a start, it would help teachers everywhere prepare classroom instruction in a much more scientific manner. Besides, it can be used by solutions providers to significantly shorten their product development and refinement cycles. It can be a global public good, an example of how India can produce, rather than just consume, cutting edge research in an important area like pedagogy.

In this regard, I am pleased to note that the Central Square Foundation (CSF) has produced the report, 'EdTech for India: Leveraging technology to bridge learning gaps'. The report is an earnest attempt at discussing how education can be democratized through the use of technology and digital resources. It discusses the enabling factors required for the use of technology in education and attempts a comprehensive mapping of existing evidence and policies that India can take inspiration from. I know that the Central Square Foundation has been working in the area of Educational Technology for the past decade now and the report reflects their understanding and experience of the sector. I congratulate Central Square Foundation on the production of this report, and encourage all stakeholders in the ecosystem to make good use of the information provided within it.

Dr. Santhosh Mathew
Country Lead, Public Policy and Finance, India
Bill and Melinda Gates Foundation
September 1, 2022

Executive Summary

With more than 250 million school going students, India has one of the largest education systems in the world. The last two decades have witnessed great strides in school enrolment leading to near universal access to schooling. However, schooling doesn't necessarily equate to learning as evident from the National Achievement Survey 2021, which finds a steady decline in state-wise performance in literacy and numeracy, as compared to 2017 levels. The low levels of learning have further been exacerbated by the COVID-19 pandemic and the resulting school closures, which led to immense learning loss among students. The paradox of universal access to schooling with low levels of learning is primarily due to challenges such as the presence of multigrade and multilevel classrooms, limited teacher capacity, limited data to inform policy, and lack of parental support. Education technology can play a significant role in addressing these challenges.

Education Technology, or EdTech, has demonstrated significant potential by augmenting traditional learning practices. The COVID-19 pandemic disrupted school education worldwide, with schools in India being shut for prolonged periods of time. Given the nature of the pandemic, home- and digital-learning came to the forefront, with both central and state governments, supported by non-government and private organizations, launching a variety of initiatives to ensure continued learning. The pandemic led to a range of opportunities relating to digital learning, including growing smartphone penetration, increasing parental participation in learning and increased political salience around blended learning. Even in a 'business as usual' situation, at-home and blended learning will need to play an important role in remediation by reinforcing concepts being taught in school. Building off the momentum created during the pandemic, a 'blended approach' that combines in-school instruction with at-home learning and caters to the individual needs of a child is a promising way forward.

However, despite steady growth and increased salience, the EdTech opportunity for the low income still remains untapped due to gaps in policy, the unaffordability of quality EdTech solutions, and inequitable device access. Given these challenges, the objective of this paper is to present a medium-term view on how EdTech can be leveraged to enhance teaching and learning practices in India. The paper focuses on democratizing use of technology for education both at homes and in schools and may be relevant for decision-makers, practitioners, and implementers. Throughout the paper, discussions are anchored around three key pillars, which are essential for the success of any EdTech intervention: Infrastructure & Connectivity, Content & Software, and Capacity.

Adoption of a clear pathway for integrating technology in education is imperative to ensure the benefits of EdTech meaningfully reach all sections of society. To arrive at this pathway, the paper analyzes past and current EdTech policies in an effort to track the policy journey and build on the key imperatives going forward. The earliest Central government initiative in EdTech can be traced back to 1972 and was focused on procurement of hardware. Gradually, the scope of initiatives expanded to include software and information dissemination, but it was not until 2004 that a comprehensive EdTech policy — ICT@Schools — was launched. However, even this policy, in the absence of a broad vision for implementation failed to support states in effective procurement of hardware and software. The next pivotal moment for EdTech policy came with the release of the National Education Policy (NEP) 2020. This policy emphasises the important role technology can play in the improvement of both educational processes and outcomes, and calls for integration of EdTech with traditional classroom teaching for better participation and improved learning outcomes of students. For learning at home, the policy emphasises access to devices for all students in order to help them learn at their own pace, while at an institutional level, the policy proposes creation of a central autonomous body, National Educational Technology Forum (NETF), for coordination of all EdTech efforts in India.

Along with comprehensive policy, the effective use of EdTech requires a robust enabling environment. The paper looks at the current state of EdTech in India, with infrastructure, relevant content and learning software, and capacity of the education system constituting essential elements of this. Though consistent efforts have been made by Central and State governments, as well as non-governmental organisations, there still remain gaps in digital infrastructure in schools and at home, in the creation and curation of content and in increasing the capacity of teachers, parents and school systems. In addition to governmental and civil society efforts, India provides a large and growing market for private EdTech products and solutions. With the pandemic providing an impetus to the EdTech market, it is now expected to grow to approximately USD 10.4 billion in size by 2025. While this figure provides optimism in terms of market size, prevailing market trends, such as current focus on higher grades, the high-cost of EdTech solutions and the lack of products in local languages, indicate that democratising EdTech will take sustained efforts.

In order to arrive at an informed way forward, the paper analyses evidence and policies from India and around the world. Existing evidence on the impact of EdTech on student learning can inform the design of effective EdTech policies and initiatives, and this evidence — both local and global — not only sheds light on the factors that are crucial for effectiveness of EdTech but also helps to identify the challenges of tech-preparedness, and resource restraints faced by teachers and parents in the adoption of EdTech. In addition to the evidence on EdTech, experience of countries with adoption and expansion of EdTech at a systemic level provides invaluable insights for policymaking, especially on the planning, budgeting, and implementation fronts. We discuss the EdTech policy approaches of Singapore, USA, China, and Indonesia to get diverse perspectives on the design and implementation of EdTech policy, and highlight how these can be contextualized for the Indian context.

As India considers widespread interventions for digital education, infrastructure, and solutions, this paper arrives at recommendations that can serve a valuable springboard for reviewing EdTech Policy planning and implementation:

1. **States may consider adopting an EdTech planning framework to design effective strategies for both in-school and at-home learning.**
2. **Important to build salience around blended learning, and establish dedicated teams and budgets for the same to unlock learning outcomes.**
3. **In order to leverage technology for achieving Foundational Literacy and Numeracy (FLN) by 2025, as envisioned by NEP 2020, there should be iteration in the policy and budget allocations for the ICT@Schools scheme.**
4. **Improve the institutional and individual capacity of the ecosystem for successful implementation and adoption of EdTech in schools and at homes.**
5. **Improve accountability of the system for efficient and effective implementation of EdTech policies and initiatives.**
6. **Build innovative models to ensure access to devices by children and design the right incentives for effective use of devices for learning.**

The aforementioned are critical in leveraging technology and democratising education as we consolidate our digital learnings for both in-school instruction and at-home learning. Going forward, we remain optimistic about the power of technology to eliminate the borders and walls of the classroom so that every child has access to the best quality education, both in school and at home. The synergistic actions of governments, for- and not-for-profit EdTech companies, academics, teachers and parents can be transformational and help us reimagine traditional ways of teaching and learning to positively impact the learning outcomes of our children.

Disclaimer

While we acknowledge the importance of exploring the different use cases of technology, especially the merits of using technology to support bridging the gender gap or its use by persons with disabilities, the current scope of this paper is limited to studying the past and current state of EdTech in India and providing recommendations to support teaching-learning overall.

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List of Abbreviations

AMC	Annual Maintenance Cost
ASER	Annual Status of Education Report
API	Application Programming Interface
APS	Affordable Private School
AWP&B	Annual Work Plan and Budget
BAN-SM	Badan Akreditasi Nasional Sekolah Madrasah
BOO	Build Own Operate Model
BOOT	Build Own Operate Transfer Model
CAL	Computer Aided Learning
CapEx	Capital Expenditure
CIET	Central Institute of Education Technology
CLASS	Computer Literacy and Studies in Secondary Schools
DCR	Digital Classroom
DIKSHA	Digital Infrastructure for Knowledge Sharing
DISE	District Information System For Education
DIET	District Institute for Education and Training
EDUSAT	Education Satellite
ESSA	Every Student Succeeds Act
ETB	Energised Textbooks
FLN	Foundational Literacy and Numeracy
FOSS	Free and Open Source Software
FYP	Five Year Plan
GeM	Government e-Market
ICT	Information and Communication Technologies
IDER	Indian Digital Education Report
IT	Information Technology
MGML	Multi Grade-Multi Level
MHRD	Ministry of Human Resource Development
MOE	Ministry of Education
MoEC	Ministry of Education and Culture
MOE-C	Ministry of Education, China
MOE-S	Ministry of Education, Singapore
MoNE	Ministry of National Education (Indonesia)
MoRA	Ministry of Religious Affairs
MP	Master Plan

NAS	National Assessment Survey
NCERT	National Council of Educational Research and Training
NCES	National Council for Education Statistics
NEP	National Education Policy
NETF	National Education Technology Forum
NETP	National Education Technological Plan
NIPUN	National Initiative for Proficiency in Reading with Understanding and Numeracy
NISHTHA	National Initiative for School Heads' and Teachers' Holistic Advancement
NRF	National Research Foundation
NSS	National Service Scheme
OLPC	One Laptop Per Child
OpEx	Operational Expenditure
PAB	Project Approval Board
PAL	Personalized Assisted Learning
PARAKH	Performance Assessment, Review, and Analysis of Knowledge for Holistic Development
RCT	Randomized Controlled Trials
RMSA	Rashtriya Madhyamik Shiksha Abhiyan
SD	Standard Deviation
SDG	Sustainable Development Goals
SIET	State Institute of Education Technology
SLA	Service Level Agreement
SSA	Samagra Shiksha Abhiyan
SWAYAM	Study Webs of Active-Learning for Young Aspiring Minds
TEI	Teacher Education Institute
TSU	Technical Support Unit
U-DISE	Unified District Information System For Education
UT	Union Territory

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Introduction

Education Technology, more commonly referred to as EdTech, has demonstrated significant potential by augmenting traditional learning practices. Following the COVID-19 pandemic and the temporary closure of schools, EdTech has evolved into a key priority for the education sector in India. While various EdTech initiatives by the Central and State Governments (eg. DIKSHA, EDUSAT, SWAYAM) had been gathering a steady momentum in the past, the COVID-19 pandemic has brought a renewed focus on the need to integrate technology into the teaching-learning continuum. The steady growth of the sector has been supported by rapidly increasing device availability and affordable data.

500 mn → **800 mn**

Smartphone users in India by 2024
(ICEA-KPMG, 2020)

42% → **51%**

Smartphone penetration in India by 2025
(Statista, 2021)

Reports show that there are approximately 500 million smartphone users in India and the number is expected to grow to over 800 million by 2024 (ICEA-KPMG, 2020). The smartphone penetration rate in the country is estimated to be at 42% and expected to reach 51% by 2025 (Statista, 2021). As per the most recent Annual Status of Education Report (ASER) study, conducted in 2021, which surveyed over 76,000 households across 26 states and four union territories in rural India, two thirds of the respondents had access to a smartphone and 88% of the respondents had access to the internet, with smartphone ownership increasing by 31.1% between 2018 and 2021 (ASER, 2021).

2/3
of the respondents had access to a smartphone

88%
of the respondents had access to the internet

31.1%
increase in smartphone ownership between 2018 and 2021

ASER study which surveyed 76,000 households across the 26 states and 4 UTs

Source: ASER, 2021

Even though the EdTech landscape in India has been growing; the EdTech opportunity for the low income sector still remains untapped. A majority of the solutions available in the market cater primarily to the higher-income segments of the population[1]. Adoption of a clear pathway for integrating technology in education is imperative to ensure the benefits of EdTech meaningfully reach all sections of society.

The objective of this paper is to present a medium-term view on how EdTech can be leveraged to enhance teaching and learning practices in India, with a focus on access to EdTech for income households both in school and at home. The paper will capture the state of the EdTech sector, discuss prominent EdTech related initiatives and market trends, synthesize Indian and global evidence, analyze EdTech policies and institutional structures internationally. Finally, the paper will provide evidence-based recommendations on the way forward for EdTech programs, policies and institutions in India.

For the purposes of this paper, the definition of 'EdTech' will be limited to the use-cases of technology in education for teaching and learning purposes at homes and in schools for the K-12 segment. While reviewing the EdTech market and learning from the global context, the paper considers the supply side as well, which is the private EdTech ecosystem; however, the recommendations are primarily focused on the public school ecosystem. Having said this, the recommendations are also relevant to the affordable private school sector, which caters to a large section of India's low-income, early grade population. There are three broad categories of EdTech which will be discussed in this paper:

1 CSF analysis of the Top 6 funded start-ups and average income levels (details in the 'EdTech Market' subsection)

Tech for Students

Student-facing technology administered either 1:1 or 1:many with the aim of improving student learning

Tech for Teachers

Teacher-facing technology with the aim of augmenting delivering teacher training, teacher capacity building, lesson planning and lesson delivery

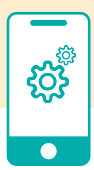
Tech for Assessments

Tech-enabled assessments leading to the generation and use of reliable data for teaching and learning

Throughout this paper, discussions are anchored around three key pillars which are essential enabling conditions for the success of any EdTech intervention:

Infrastructure & Connectivity

Availability of quality physical and digital infrastructure and equitable access to it in schools and at homes are necessary conditions for leveraging EdTech



Content & Software

The quality of educational content and the ability of the software deployed on the device to respond to existing learning level of the student is crucial for potential impact on learning outcomes

Capacity

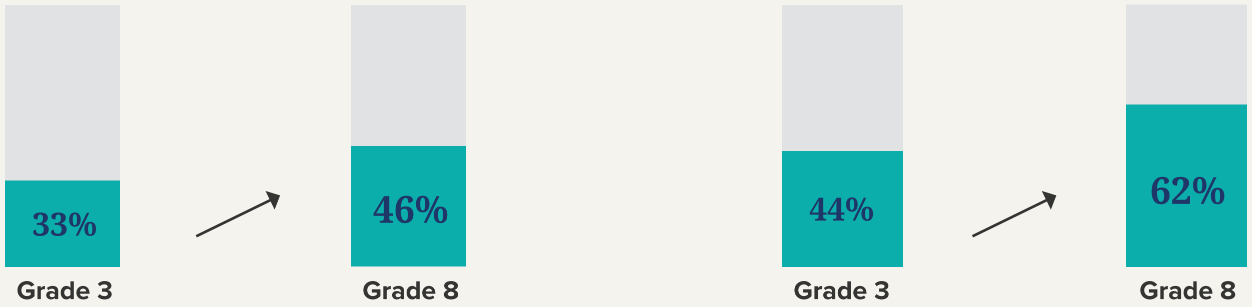
Effective use of physical and digital infrastructure, and content and software require capacity of different stakeholders of the ecosystem. This capacity involves:

Ability of the teachers to effectively integrate EdTech with classroom learning

Ability of parents to meaningfully engage with their children's learning

Strengthening the institutional capacity for efficient procurement and implementation of EdTech programs and inducing behavior change in the various stakeholders in the system.

1 Overview of the State of School Education in India



Students who **cannot** read with comprehension

Students who **cannot** use basic math to solve daily life problems

Source: National Achievement Survey data from 2017

In the last two decades, India has reached near universal access to schooling, with enrollment for children aged 6-14 being at nearly 97%. This makes the Indian education system one of the largest in the world with over 250 million school-going children and 9.2 million teachers (U-DISE, 2018). However, research suggests that schooling does not necessarily equate to learning (van der Gaag and Putcha, 2013; Pritchett, 2013; van der Gaag and Adams, 2010). According to the National Achievement Survey (NAS) data from 2017, 33% of students in grade 3 cannot read with comprehension, and this number increases to 46% by grade 8; and 44% of students in grade 3 cannot use basic math to solve daily life problems; and this number increases to 62% by grade 8 (NAS, 2017) NAS 2021 further highlights the need for urgent intervention to improve foundational learning levels, with a comparative analysis showing that the national average scores of students across subjects have dropped by 47 marks. With the exception of Punjab and Rajasthan, the state-wise performance across the country has declined compared to 2017 levels (Indian Express, 2021).

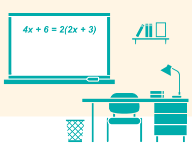
This is further corroborated in ASER 2018 by Pratham, which shows that more than half the children in rural India cannot read at a second-grade level after five years of schooling (ASER, 2018). The gap in learning outcomes continued in the next year as well, as seen in data from ASER 2019, which highlights that the majority of children in grade 3 could not read a grade 1 level text, putting them at least two years behind where the curriculum expected them to be (ASER, 2019).

A sample study from one Indian state presented data across years, highlighting the learning loss that has taken place due to the COVID-19 school closures; this showed steep drops in the learning levels of primary grade students where foundations are still shaky.

The proportion of grade 3 students who could read grade 1 texts had fallen sharply from 41% in 2018 to 24% in 2020; and the proportion of students in grade 3 who could recognize double digit numbers reduced by 18%, with it being 78% in 2018 and 60% in 2020 (ASER, 2021).

Research indicates that children who fall behind, stay behind and are not able to catch up in the later grades; Muralidharan (2018) suggests that any initiative to improve learning outcomes can be successful if it overcomes this constraint of the education system that children are not left behind in the foundational years, i.e., grade 1 to 3. A stark suggestive evidence of this constraint is that in any given grade, the learning levels of students span four or five grade levels (Muralidharan et al., 2019). For a teacher teaching in a higher grade in a government school, this translates to teaching a classroom full of students at different grade levels i.e. Multi-Grade and Multi-Level (MGML) classrooms, but where the goal is to responsibly finish the curriculum of that one particular grade.

In addition to the MGML classrooms there are a multitude of challenges being faced by the education system. Following are some of the key challenges:



Teacher staffing constraints

15% of teaching positions are vacant (Muralidharan et al., 2019); 25% of teachers are absent from classrooms (MHRD, 2016). In addition, teacher incentives in the public school system are often not aligned to outcomes.

Limited availability of data to enable informed decision making

There is limited information on teacher knowledge gaps and student learning levels. Due to the lack of reliable data, curriculum designs and lesson plans are often not data-driven or based on student learning pathways currently.

Parental support

The ASER 2020 report suggests that when parents have a lower level of education, children are less likely to receive support at homes (ASER, 2021). As at-home learning has become even more important during the Covid-19 pandemic globally and across Indian states (refer to At-home learning section), parental capacity and engagement are likely to have a bearing on effective adoption of EdTech in the household.

Technology can play a catalytic role in addressing some of these constraints to quality education in India. While there are several EdTech archetypes and use-cases, having a framework for understanding how technology could be used to strengthen various interactions in the teaching learning process is valuable. Based on a thorough review of more than 350 innovations in EdTech worldwide, a recent report identifies nine key teaching-learning interactions that can be transformed through technology (CSF, 2021). These interactions are as follows:

Lesson Preparation	Technology allows for creation and dissemination of high-quality plans for more effective instruction with reduced teacher effort. Leveraging technology for lesson preparation can lead to systemic increase in lesson quality
Lesson Delivery	Technology enables teachers to deliver better instruction and transformers their role from an instructor to a guide that supports students through a personalized learning journey in the classroom
Teacher Professional Development	Technology can allow for large-scale delivery of teacher professional development that provides flexibility and agency to teachers for their own learning
Homework	A nascent but disruptive category which envisions automatic creation, dissemination, and correction of homework, allowing teachers to plan for more targeted interventions to support learning
Assessments	Technology enables and automates the creation of increasingly engaging assessments. Easy collection of reliable performance data can feed into and redefine lesson preparation and delivery
Self-Learning	Technology increases the student's agency in directing their learning, via a basket of innovative solutions offering engaging and personalized learning experiences
Doubt Resolution	Technology enables greater student independence by provision of on-demand services through virtual communities and AI-backed solution repositories to resolve doubts
Parent-Teacher Communication	Technology enables increased depth and quality of communication between teachers and parents
Parental Participation	Technology enables parents to increase their own capacity to meaningfully engage in their child's learning journey

Thus, technology can be leveraged to improve key teaching-learning interactions by reshaping traditional classroom practices in order to create meaningful learning journeys for children.

2 National Education Policy 2020

In July 2020, the Government of India announced the National Education Policy (NEP) — a mandate for education for K-12 and beyond. Aligned to the Sustainable Development Goal 4 (SDG4), the NEP is a roadmap for the country to achieve 'universal access to quality education' by 2030.

The policy places emphasis on the important role that technology can play in the improvement of both educational processes and outcomes, thus aiding the timely implementation of its goals. In the classroom setting, the policy calls for integration of EdTech with traditional classroom teaching for better participation and improved learning outcomes of students. For learning at home, the policy emphasizes access to devices for all students in order to help them learn at their own pace.

At an institutional level, the policy proposes creation of a central autonomous body, National Educational Technology Forum (NETF), for coordination of all EdTech efforts in India.

The NEP, launched in the background of COVID-19 pandemic, which led to unprecedented disruptions in school education, recognizes the urgent need for online and digital education, ensuring equitable use of technology. The policy also anticipates that *"new technologies, such as artificial intelligence, machine learning, block chains, smart boards, adaptive computer testing for student development, etc., will not only change what students learn in the classroom but also how they learn it"*. (NEP Para 23.2, 2020) Therefore, the policy suggests paying particular attention to disruptive technologies to stay abreast of the changes and their potential impact on the education system in India.

Key Highlights of EdTech in NEP 2020

The NEP has articulated the role of EdTech as a key enabler for the overall development of the education system in India. We discuss the key highlights from NEP 2020 across the three pillars of EdTech.

Infrastructure & Connectivity

Given the recent and ongoing pandemic, the NEP emphasizes the increased importance of EdTech for continued at-home learning for all students. It notes that the information and communications technology (ICT) infrastructure must be made available for all students leveraging the existing and new digital initiatives. The policy *"calls for carefully designed and appropriately scaled pilot studies to determine how the benefits of online/ digital education can be reaped while addressing or mitigating the downsides. In the meantime, the existing digital platforms and ongoing ICT-based educational initiatives must be optimized and expanded to meet the current and future challenges in providing quality education for all"* (NEP Para 24.1, 2020).

Further, in order to address the digital divide, low tech mediums like television, radio, and community radio, etc., can also be leveraged for dissemination of content.

Software & Content

The policy reiterates the need for creation of content at State level in all Indian languages and making them accessible for all students through platforms like DIKSHA/SWAYAM etc. It states that *"a special focus on content in all Indian languages will be emphasized and required; digital content will need to reach the teachers and students in their medium of instruction as far as possible"* (NEP Para 24.4. (e), 2020). Providing a vision for the future, the policy highlights that the focus of teaching-learning process must shift to a blended learning approach and the education curriculum should prioritize awareness of disruptive technologies in schools.

The policy also recognizes the need for taking innovative measures for conducting online assessments through appropriate bodies like the National Assessment Centre, Performance Assessment, Review, and Analysis of Knowledge for Holistic Development (PARAKH). It specifies the role of PARAKH as a center to *"formulate guidelines and recommend appropriate tools for conducting assessment, from the foundational stage to higher education (including for entrance exams), in order to ensure equitable access and opportunities for all students with learning disabilities"* (NEP Para 6.13, 2020).

Capacity

The policy focuses on building both institutional and individual capacity for effective implementation of EdTech in the country.

A. Institutional Capacity

- Creation of an autonomous body, National Educational Technology Forum, for both school education and higher education in order to facilitate decision making on the induction, deployment, and use of technology.
- Creation of a National Research Foundation (NRF) for school and higher education ensuring that there is an increased focus on new disruptive technologies.
- Creation of a dedicated unit for the purpose of orchestrating the building of digital infrastructure, digital content and capacity building to address holistically the e-education needs of both school and higher education.

B. Individual Capacity

The policy also calls attention to the need for building capacity of teachers and school leaders for effective use of technology in education and also leverage technological interventions for improved teaching learning processes. To do so, the policy suggests that *"teachers will undergo rigorous training in learner-centric pedagogy and on how to become high-quality online content creators themselves using online teaching platforms and tools. There will be emphasis on the teacher's role in facilitating active student engagement with the content and with each other"* (NEP Para 24.4 (g), 2020).

NEP and the Digital Infrastructure for Education

The NEP 2020 emphasizes the role that technology can play in solving critical challenges of the education system and identifies that *"there is a need to invest in creation of open, interoperable, evolvable, public digital infrastructure in the education sector that can be used by multiple platforms and point solutions, to solve for India's scale, diversity, complexity and device penetration. This will ensure that the technology-based solutions do not become outdated with the rapid advances in technology"* (NEP Para 24.4.b, 2020; MHRD, 2020).

"...there is a need to invest in creation of open, interoperable, evolvable, public digital infrastructure in the education sector that can be used by multiple platforms and point solutions, to solve for India's scale, diversity, complexity and device penetration. This will ensure that the technology-based solutions do not become outdated with the rapid advances in technology."

(NEP Para 24.4.b, 2020; MHRD, 2020)

Also relevant to the NEP, is the National Initiative for Proficiency in Reading with Understanding and Numeracy (NIPUN) that recognizes the crucial role of foundational skills, and aims to ensure that every child in the country attains foundational literacy and numeracy by 2026-2027. The NEP clearly recognizes the importance of early and foundational learning, and hence the NIPUN mission links closely to aligning with the goals of the larger national strategy. Technology has been identified in the NIPUN guidelines as playing an important role in imparting high-quality pedagogically aligned curriculum, in creating a robust IT system that can track data meaningfully, in ensuring that parents and caregivers are involved in learning, and in streamlining teacher assessments (MoE, 2021). Hence, a unified digital infrastructure for education will not only support the larger goals of the NEP, but will also lead to the improvement in learning outcomes of younger learners, bolstering the goals of the NIPUN mission.

The Ministry of Education (MoE) has already been engaging in multiple digital initiatives and platforms such as DIKSHA, SWAYAM, NISHTHA and others for strengthening teaching and learning in classrooms and at home. Additionally, the central government has developed the Unified District Information System for Education Plus (U-DISE+) for effective governance of school education. While the government has been leveraging technology in multiple areas of the education sector, the recent COVID-19 pandemic has further leapfrogged innovations in technology for education. MoE's India Report on Digital Education (IDER) June 2020, documents several national and state level initiatives taken to leverage technology to mitigate the disruptions faced in learning due to pandemic induced school closures (MHRD, 2020).

Many innovations have also happened with the non-profit and private sector in building solutions for both teachers and students. The EdTech industry has been growing at a fast pace with over 4000 EdTech solutions available in the K-12 space. Therefore, this is an opportune time to build upon the several initiatives that are already underway. In an effort to build a comprehensive technological infrastructure and architecture that allows stakeholders to participate in and create solutions in an integrated manner, the central government has a vision of creating NDEAR — a National Digital Education Architecture.

This architecture will be a technological framework that aims to enable existing systems to upgrade and become interoperable, while making available the building blocks needed for the creation of new tools and solutions. This will support the education ecosystem in creating and delivering diverse, contextual and innovative solutions that benefit students, teachers, parents, communities, administrators (NDEAR, 2021).

Hence, a unifying digital infrastructure for education, if created as envisioned in NEP 2020, will help in improving the quality of education services and also create value for all institutions and individual stakeholders. To build this digital infrastructure, it is critical to have a deep understanding of the gaps and needs of the education system that evolve with time. It is crucial for the government to play a pivotal role in the creation of such an infrastructure by not only making significant investment in it as it is a public good but also by providing strategic direction to this initiative (MHRD, 2020).

3 EdTech Policies and Initiatives in India

EdTech Policies

The earliest trace of EdTech related policy by the Central Government of India goes back to the year 1972. This program, which started with radio programs was upgraded to a centrally sponsored scheme called Computer Literacy and Studies in Secondary Schools (CLASS) in 1984 through which computers to 12,000 government and aided secondary schools were provided using international aid and grants (Srivastava & Tomar, 2005). Table 1 in the next page provides a snapshot of how EdTech related policies have evolved in India starting from 1972. While the paper mentions different EdTech policies in India to date, the discussion focuses on ICT@Schools 2018 and the EdTech related portions of the NEP 2020 given their immediate relevance.

Table 1: EdTech Schemes and Policies in India

Year	Policy Name	Key Features
1972	**Educational Technology (ET)**	• Assistance was given to 6 State Institute's of Education Technology (SIETs) out of which 4 SIETs are currently functional in Andhra Pradesh, Gujarat, Kerala, and Uttar Pradesh • Assistance for procurement of radio-cum-cassette players and TVs was given to the States/UTs
1984-2004	**Computer Literacy and Studies in Secondary Schools (CLASS)**	• CLASS was initially introduced as a pilot project in 1984-85 • In 1993, the project was adopted as a centrally sponsored scheme during the 8th FYP (1993-98) and its scope was widened to provide financial grants to educational institutions and also to cover new Government and Government aided secondary and higher secondary schools (NCERT, n.d.) • The use and supply of software to higher secondary Schools. • In 1998, The National Task Force on Information Technology and Software Development constituted by the PM, made recommendations on introduction of IT in the education sector through schemes like Vidyarthi Computer Scheme, Shikshak Computer Scheme and Schools Computer Schemes (NCERT, n.d.)
2004, 2010, 2011	**ICT@ Schools**	• 2004: All Secondary and higher schools should have computer-aided education • 2010 and 2011: Quality digital content needs to be created and need for incentivization of teachers was highlighted • Budget allocated for ICT infrastructure in Upper Primary schools as a part of the Computer Aided Learning (CAL) program under the Samagra Shiksha Abhiyan (SSA)
2018	**Integrated ICT Plan under SSA**	• Covers Govt. Schools having grades from 6 to 12 • Provision of non- recurring amount of ₹ 6.4 lakh and recurring amount of ₹ 2.4 lakh per school (recurring cost for 5 years after implementation) for establishing ICT labs in school

Source: Revised Scheme of ICT In Schools, MHRD, Samagra Shiksha Document, MHRD

The first comprehensive EdTech policy was ICT@Schools launched in 2004. The policy recommended that all secondary and higher schools should have computer-aided education with 75% funding provided by the Central Government and 25% by States and Union Territories Governments (Srivastava & Tomar, 2005). In 2010 and 2011, this scheme was revised to introduce two critical reforms of developing quality digital content and incentivizing teachers through the National ICT Award for School Teachers. Since the policy was a part of Rashtriya Madhyamik Shiksha Abhiyan (RMSA) that focused on secondary education, its scope was limited to secondary schools and did not cover primary schools.

ICT@Schools 2018

India's latest policy on EdTech in 2018, ICT@School Scheme has been integrated with SSA (NCERT, n.d.). The current scope of ICT@Schools policy encompasses students, teachers, and teacher educators. The key features of the policy are highlighted below.

Coverage of the Scheme

The scheme covers all Government Schools from Grades 6-12 and Teacher Education Institutes (TEIs) but does not cover primary grades in its ambit. Under the ICT@Schools scheme (MHRD, 2018), 88,993 (60.8%) secondary and senior secondary schools of both government and government aided have been covered out of the total of 1,46,303 schools.

Mode of Procurement

The policy suggested that States, UTs and Autonomous bodies use one of the following models (uni / multi model) for implementing the program as per their requirement which includes: outright purchase through Government e-Market (GeM)/ Build Own Operate Transfer (BOOT) / Build Own Operate (BOO) Model.

ICT Budget

The policy prescribes a total of ₹ 6.4 Lakh per school for capital expenditure (Capex), including the Annual Maintenance Cost (AMC), for a period of 5 years, and ₹ 2.4 lakh per school per year for 5 years for operational expenditure (Opex) to all States/UTs for grades 6-12 in all government schools. States are also provided flexibility in terms of utilizing the budget for suitable hardware and software under the budget ceiling. The ICT budget, including the recent revisions of Samagra Shiksha norms, are discussed in detail in the Budgetary Trends section later in the paper.

EdTech Software

The policy encourages states to procure Free and Open Source Software (FOSS) for EdTech, even though a budget line item does reference paid software.

Analysis of ICT@School 2018 Policy

ICT@Schools scheme mandated that each state and union territory should conduct an independent external evaluation of the implementation of the scheme. The implementation evaluation reports for many states are available on the ICT@Schools online repository. A comparative analysis of implementation of ICT@Schools in 10 states by the National Council of Educational Research and Training (NCERT) reveals a sobering picture (CIET, 2014).

The report suggests that in absence of a broad vision for implementation of ICT@Schools from the central government, most states were found lacking a state specific vision for implementing the scheme and took an ad-hoc operational approach to its implementation.

The scheme's requirement of hardware — 10 computers per lab in schools — was met by most states and 70-80% of the computers were functional at the time of the state evaluations. However, states varied significantly in terms of the availability and functionality of supporting infrastructure like electricity generators, internet connections, projectors, etc. Similarly, availability of ICT curriculum varied widely across states. While most states procured digital content through BOOT operators, the feedback on quality of content gathered as a part of the state evaluations was inconclusive. The comparative analysis also finds that despite the availability of computers in labs, students do not have sufficient access to these computers and that only a small percentage of teachers use technology for lesson planning. Moreover, at the systems level, the principals' awareness of the scheme in most states was minimal.

Updated Guidelines to the ICT Policy in 2020

Though there has been no change to the ICT@Schools policy, new guidelines were issued for states to follow in 2020. The new guidelines provide the states, which have already availed of the ICT@Schools policy regarding procurements for Smart Classrooms, another opportunity to do so for schools with more than 700 students. However, the new financial norms are not aligned with the new programmatic norms, which has resulted in states not availing the second chance provided by the center due to a lack of funding for another Smart Classroom. Ideally, the financial norms should reflect the expanded programmatic norms, and provide more funding to the existing ₹ 6.4 Lakh non-recurring grant and ₹ 2.4 Lakh recurring grant per school already provided prior to the changes made in 2020.

EdTech Initiatives by the Government

Over the years, the central and state governments of India have undertaken several EdTech initiatives. While the objective of these initiatives have been to use technology in different aspects of the teaching-learning process and education systems, many of these initiatives were conceived and implemented in isolation. Table 2 provides an overview of EdTech initiatives undertaken by the Central government since the year 2000.

Table 2: EdTech Initiatives of the Central Government in India

S.No	Initiative	Year	Scope	Use Case
1	**Gyan Darshan (IGNOU_MHRD-Prasar Bharti)**	**2000**	Educational channel providing access to learning material, courses, live sessions for students & professionals	Information Dissemination
2	**Gyan Vani**	**2003**	IGNOU's multilingual radio broadcast hosts programs from various educational institutions	Information Dissemination
3	**Enhancement of Primary Education (ISRO-MHRD-IGNOU)**	**2004-10**	EDUSAT supplemented curriculum based teaching through television broadcasts, video conferencing, web-based instructions, etc., via satellite	Teaching-Learning
4	**Aakash Tablets**	**2011**	MHRD launched low cost laptops distribution program for students & teachers to improve digital access and know how	Digital Accessibility
5	**NROER- National Repository of Open Educational Resources**	**2013-Present**	Open, multilingual repository of e-learning material in video, audio, interactive format	E-Resources
6	**SWAYAM**	**2015-Present**	Interactive platform that hosts all courses till grade 9 through lectures, discussions, reading material & self-assessment	Teaching-Learning
7	**SWAYAM Prabha**	**2015-Present**	Subsumed under PMe-Vidya, 34 DTH channels broadcasting educational programs	Information Dissemination

8	**e-Pathshala**	**2015-Present**	Audio-visual resources application by NCERT: multilingual textbooks for grades 1-12, teacher training modules, supplements etc.	E-Resources
9	**DIKSHA**	**2017-Present**	Open source technology supporting multilingual teaching and learning, can be customized as per State/UT to create an online education platform	Teaching-Learning, Assessments, E-Resources, Teacher Training
10	**Shiksha Vaani**	**2019-Present**	CBSE Podcast sharing updated information regarding events & processes with parents & students	Information Dissemination
11	**NISHTHA**	**2020**	18 modules integrated training through 18 modules for teachers of grades 1-8	Teacher Training
12	**Vidya Daan 2.0**	**2020**	Allows individuals & orgs to donate e-resources and learning material for DIKSHA platforms	E-Resources
13	**PM E-Vidya**	**2020**	Multi module access to digital education: content for visually & hearing impaired; learning through TV, radio & podcasts; encompasses DIKSHA	E-Resources, Teaching-Learning

Source: Central Square Foundation, 2021

Digital Infrastructure for Knowledge Sharing (DIKSHA)

In 2017, the MoE launched the Digital Infrastructure for Knowledge Sharing (DIKSHA) initiative as a National Platform for Teachers. Its objective was to connect teachers across India and enable them to create, share, and verify educational content. The DIKSHA platform and the associated mobile app also provide teachers with training modules, serving as a one-stop shop for all teacher-related services. The DIKSHA platform, which was initially geared towards teachers can now be accessed by any Indian citizen with a valid email address (Ramanujam, 2019). Subsequently, Energized Textbooks (ETBs), which have QR codes linked to DIKSHA-hosted content, were introduced. ETBs allow students to access digital content — an animation, video or a quiz, to help students learn specific concepts — hosted on DIKSHA through an internet enabled smartphone. While the students can access this online content for learning, teachers can use the same content to prepare their classroom lessons, remediation for low-performing students, and even present exemplary videos in classrooms.

In the wake of the COVID-19 pandemic, DIKSHA has been the cornerstone of at-home learning initiatives of the central and state governments in India. In May 2020, PM e-vidya was announced with DIKSHA as 'one nation, one digital platform' and DIKSHA's scope evolved to include: teaching and learning through energized textbooks, exam preparation, continuity in learning through coherent access, quizzes and assessments, teacher professional development through NISHTHA and content sourcing through VidyaDaan.

According to usage statistics as of June 2022, the DIKSHA platform has been used 4.94 billion times for learning activities with 5.74 billion minutes of usage time. The platform is powered by over 220,000 content contributions from 11,247 contributors spread across the country. Moreover, the platform has a total of 7,431 courses with over 150.9 million enrolments and 123 million course completions (DIKSHA, 2022). The DIKSHA platform has been innovatively used by the State and UT governments. The learnings from these diverse uses of DIKSHA have been compiled in the June 2020 Report, 'Remote Learning Initiatives Across India' (MHRD, June 2020).

DIKSHA

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EdTech Initiatives by Non-Governmental Organizations

In parallel to the government initiatives discussed above, there have been many non-government EdTech initiatives. We discuss some of these initiatives in Table 3 below.

Table 3: EdTech Initiatives by Non-Governmental Organizations

Key Pillars	Initiative	Year	Scope
Infrastructure & Connectivity	Hole-in-the-Wall Education Limited	2001	Bridges digital divide, enables self & group exploration through a minimally invasive learning environment
	Digital Equalizer	2004	Targets students in grades 6-10, provide computer centres and equipping students & teachers with technical skills
	One Laptop Per Child	2010	Bridges digital divide by providing laptops to students from low income families
	Clix	2015	The initiative centers around a 1:1 student learning program conducted in computer labs in government schools

Key Pillars	Initiative	Year	Scope
Content & Software	Sankalp	2010	Interventions to improve Math & Science outcomes through content libraries, live sessions, peer instructions
	ThinkZone	2014	Age based competencies for children aged 3-10 years
	Chimple	2015	Gamified app with the mission of leveraging technology for early grade learning (FLN)
	PraDigi - Pratham Digital	2017	Digital age-based lessons for students of 3-14 years in a community setting
	Akshara - Building Blocks	2019	Math practice application with the use of games
	Google Read Along	2019	Android language learning app that uses speech recognition technology to help children independently learn and build their reading skills
	Tic Tac Learn	2020	A free and open source educational video repository, contextualized in seven Indian languages with bite-sized Math and language content

Key Pillars	Initiative	Year	Scope
Capacity	The Teacher App	**2017**	Open source, digital learning experiences to promote professional development for teachers from low resource schools
	Saarthi Education	**2017**	A community-led WhatsApp based platform that sends children daily practice worksheets in Math, supported by a strong service layer and tight feedback loops
	Firki	**2020**	Teacher education platform that provides courses, feedback, classroom observation & mentorship
	Top Parent	**2020**	A parent-facing app aimed at encouraging the use of FLN learning solutions through parental nudges and engagement
	Rocket Learning	**2020**	A government anchored, teacher facilitated WhatsApp based EdTech solution for engaging parents and communities through unique social incentive campaigns

Source: Central Square Foundation, 2021

It is observed that while early non-government initiatives were focused on improving access to digital infrastructure, the initiatives in the past decade or so have been technological platforms focused on the content and capacity dimensions of student learning.

4 Current State of EdTech in India

The policies, schemes, and initiatives of the government have shaped the EdTech ecosystem in India. While the policies and schemes provided a vision and framework for development of EdTech in India, the initiatives often had more specific aims, primarily expansion of access and dissemination of content. These state interventions influenced the incentive structures in the ecosystem thereby creating an enabling environment for non-government and private players to evolve and innovate.

Government Ecosystem

Infrastructure and Connectivity

As per the U-DISE 2017-18 data, currently there is limited availability of computer labs and electricity in schools which are key enablers for the implementation of EdTech programs. The key trends from the data can be found below:

1. **In 15 states in India, less than 10% of schools have computer labs, making hardware a barrier to facilitating effective school level technology learning programs. Only 4 out of 15 States have computer labs in more than 30% schools where effective EdTech programs at school could be run at scale.**

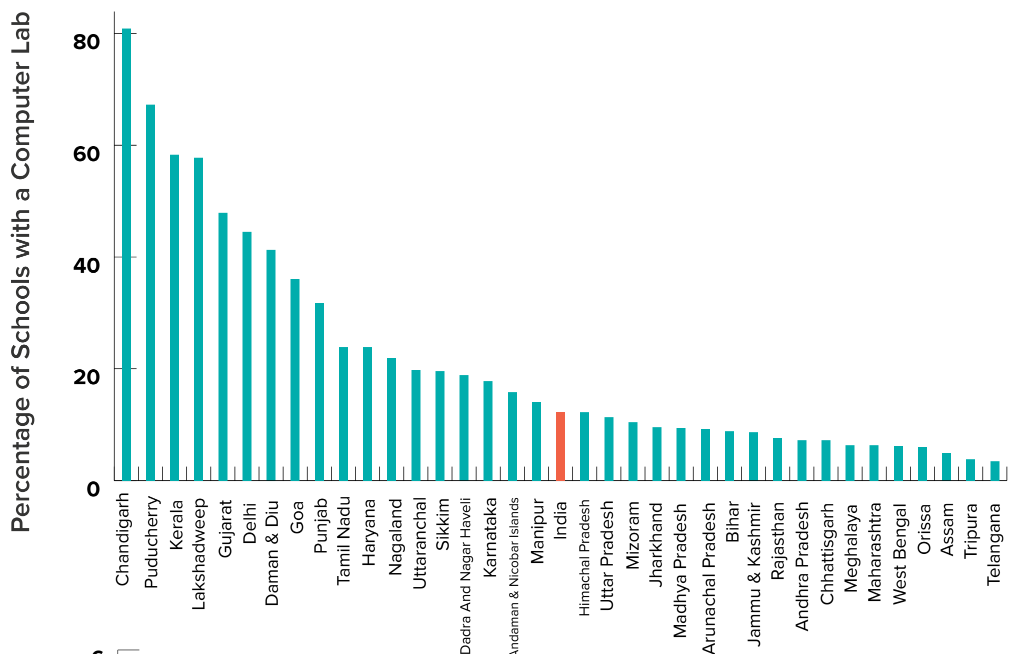


Figure 1: Percentage of Schools with a Computer Lab (Government and Aided)

Source: UDISE 2017-18

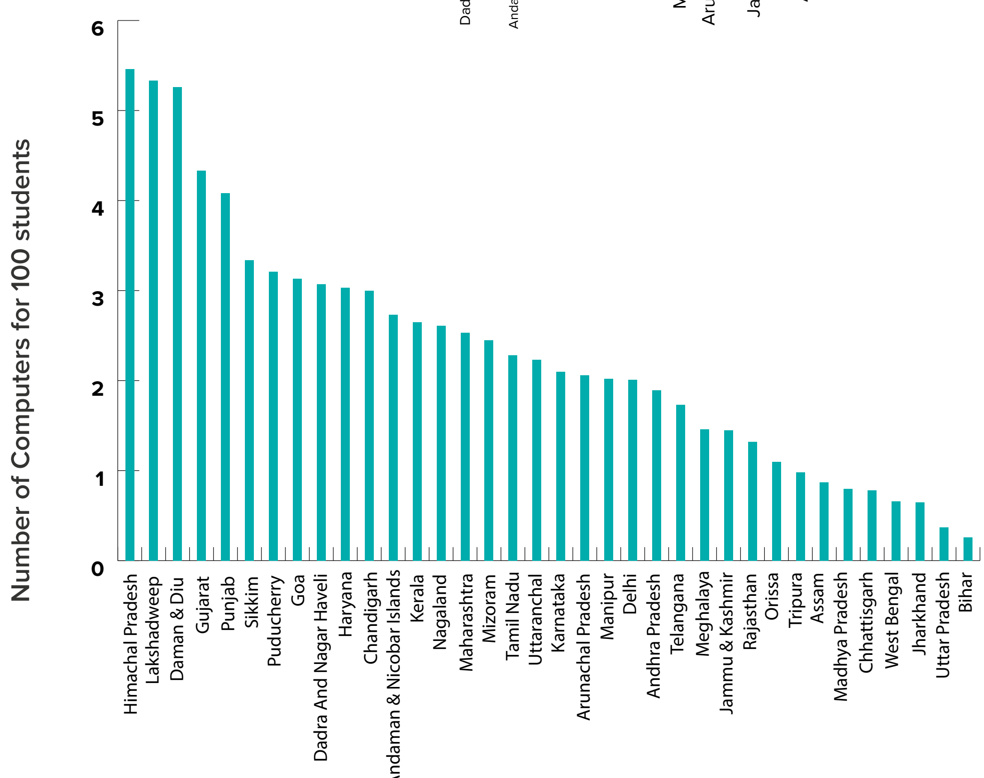


Figure 2: Number of Computers for 100 Students (Government and Aided)

Source: UDISE 2017-18

2. **On average, electricity available is ~70%, making it difficult for effective EdTech implementation. As many as 18 states (excluding UTs) have more than 50% electricity where effective EdTech programs at school could be run at scale.**

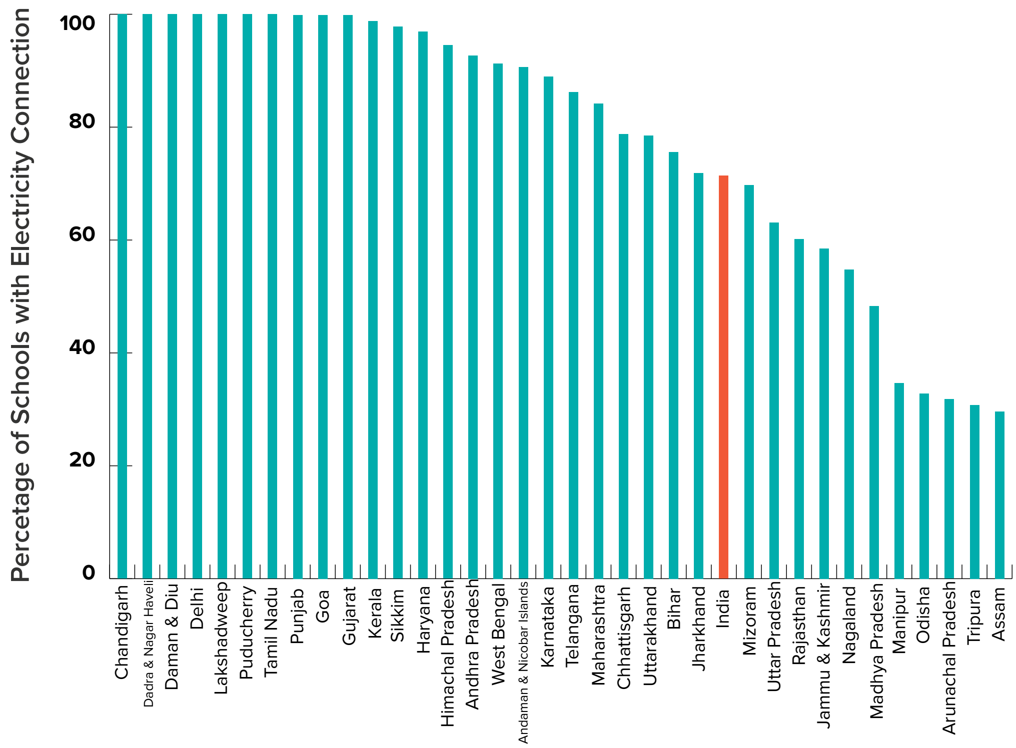


Figure 3: Percentage of schools with functional electricity connection available (Government and Aided) (all States and UTs, except Meghalaya)

Source: UDISE 2018-19

3. **Only 4 States in India have internet connectivity in more than 60% schools (with 2 States having internet in more than 90% schools). Around 27 States have internet connectivity in less than 20% of their schools.**

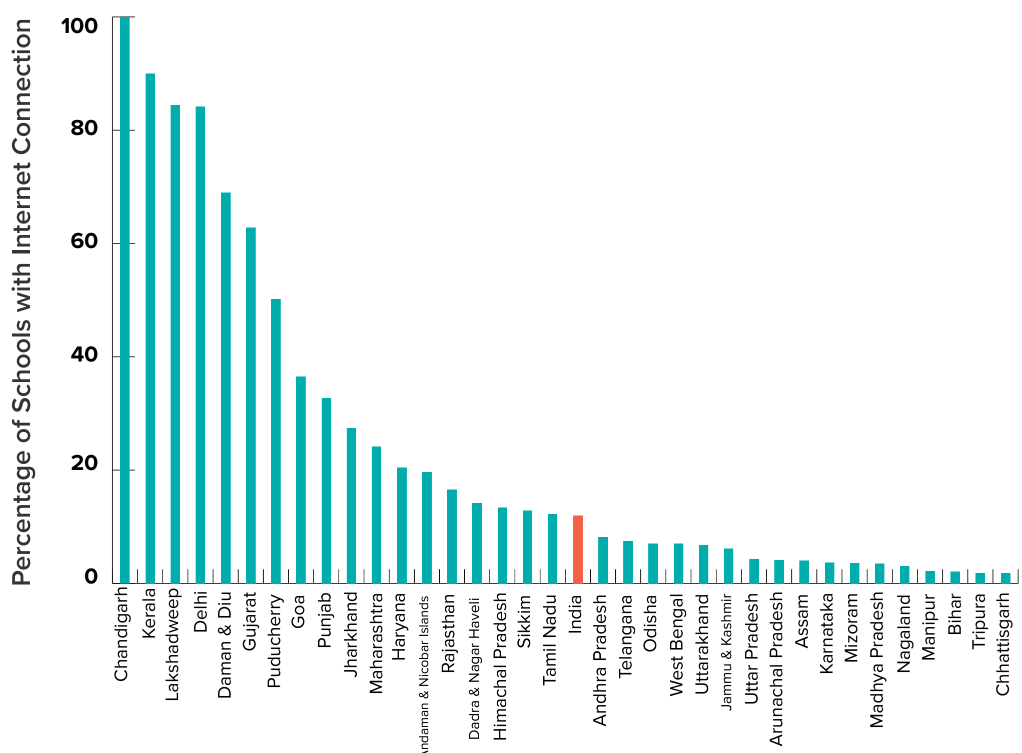


Figure 4: Percentage of schools with internet availability (Government and Aided) (Government and Aided Schools) (all States and UTs, except Meghalaya)

Source: UDISE 2018-19

While UDISE data is self-reported data by schools, the ASER 2018[1], (Table 4) where the data is recorded by independent volunteers who visit the largest rural schools, mirrors the trends that are observed in the DISE data. 79% of the largest rural schools have no computer available for children to use and less than 7% of these schools are using computers on any given day. Given that these numbers are fairly low, their implications will be revisited while discussing various policies, initiatives, and recommendations.

Table 4: Computer Availability Trends in Government Schools

%Schools with	2010	2014	2016	2018
No computer available for children to use	84.2	80.4	80	78.7
Available but not being used by children on day of visit	7.2	12.6	11.9	14.8
Computer being used by children on day of visit	8.6	7	8.1	6.5
Total children on day of visit	100	100	100	100

Source: ASER Rural, 2018

In addition to the availability of computer labs and electricity in schools, it is also important to understand internet connectivity and smartphone penetration to understand EdTech readiness at schools and homes. As of 2017, only 41.4% of all secondary schools in India had access to the internet. This is in stark contrast to China, where half the schools in the country had broadband coverage by 2015 (GETChina Insights, 2017). A report based on the National Sample Survey's (NSS's) 75th round national survey (2017-2018) finds that while fewer than 15% of rural Indian households have internet access, 42% urban Indian households can access the internet (NSO, 2018). In 2020, despite the total number of internet subscribers being at 795.18 million, the total number of subscribers per 100 people in urban areas is 103.98 and in rural areas is 34.6 (TRAI, 2020). At the same time, smartphone users are increasing in India, an estimated 500 million in 2019 by a recent report (ICEA-KPMG 2020), and expected to grow to 820 million by 2022. However, only a small proportion of this user base is using smartphones for educational purposes – about 10 million as per a recent estimate (Goldman Sachs, 2020).

Moreover, as per the ASER 2021 report, even though the household penetration of mobile phones increased from 36.5% to 61.8% (over the last two years), only a third of children received learning material among the households surveyed during the reference period[2], implying there is a large proportion of the population which is yet to reap the advantages of using technology for learning.

While access does seem to be steadily increasing, with data from NAS 2021 showing 72% of children have access to digital services at home, a significant number of children in India remain on the wrong side of the digital divide and are unable to access technology for quality learning.

1 In each sampled village, the largest government school with primary sections is visited on the day of the survey. Information about schools in this report is based on these visits.

2 The ASER 2020 surveyed rural households prior to the survey (the reference period), which was carried out in September 2020.

Content & Software

There is a limited supply of affordable EdTech solutions which can cater to all income segments of the population. In addition, there is a major dearth of high-quality products in vernacular languages. Currently, parents in low-income communities are unable to afford a majority of the EdTech products available in the market. A detailed discussion around the latest trends will be done in the subsection on the Private Ecosystem.

In the past, the Indian education ecosystem suffered from a lack of common standards or tools to assess the quality of learning that solutions provide, which could assist states in procurement decisions or retail users in their adoption decisions. Absence of such quality standards for EdTech products limits the ability of the potential users (states, schools, parents, students) to make informed decisions about these products. Hence, there is a need to support decision makers with evidence-based advice to tackle the problem of information asymmetry around the quality of EdTech learning products.

EdTech Tulna

EdTech Tulna, developed by IIT Bombay as a public resource for evaluating EdTech products, introduces a novel way for governments, schools, parents and teachers to make high-stakes EdTech adoption decisions. EdTech Tulna enables evidence-led decision-making by EdTech adopters and supports suppliers of EdTech products to build quality aligned solutions.

EdTech Tulna does this by:

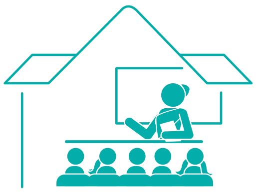
1. Providing standards for what good EdTech looks like for various use cases of EdTech
2. Public evaluations of existing EdTech products
3. Training to build the capacity of institutional stakeholders to use Tulna tools to evaluate products for own use

Tulna has already seen traction from state governments who are using it to select high-quality EdTech software. The Government of Haryana has successfully used EdTech Tulna for technical evaluation to select a quality EdTech software for a PAL (personalized adaptive learning) program, which will impact 5 lakh students. The government of Madhya Pradesh is also in the process of using EdTech Tulna's framework as pre-qualification criteria for PAL procurement.

Central and State governments have also built out various EdTech initiatives, e.g., DIKSHA, NISHTHA, e-Pathshala, etc. While these initiatives have significant outreach, robust programs need to be designed to ensure that these initiatives lead to improvements in learning outcomes.

Capacity

A. Institutional Capacity



The MoE governs the public education system in India including digital initiatives and policies governing education technology, e.g., ICT@Schools policy. While the Central Institute of Education Technology (CIET), a constituent unit of NCERT, is the primary central body for EdTech in India, its focus has been towards content development and dissemination. At the state level, CIET initiatives are supposed to be implemented through the State Institute of Educational Technology (SIETs). As of date, only four out of 29 states have established SIETs (NCERT, n.d.). Moreover, the current mandate of SIETs is limited to content development, training, and dissemination of ICT programs. Often the SIETs have limited legal, research and technical expertize to procure effective EdTech solutions and scale them across the state. The NEP 2020 has highlighted the need to create a nodal body for EdTech in India, called the National Education Technology Forum (NETF).

The mandate of NETF is to support State and Central governments with induction, deployment, and use of technology by setting standards, with respect to content, technology, and pedagogy for teaching and learning, leading research on the latest knowledge, best practices and innovations in the domain, and build the ecosystem's intellectual and institutional capacity in EdTech (MHRD, 2020).

With the EdTech market in India expanding rapidly, integrating technology effectively in education requires deliberate planning and investment, and NETF can be key in ensuring a long-term cohesive vision for EdTech.

B. Individual Capacity

Teacher Capacity

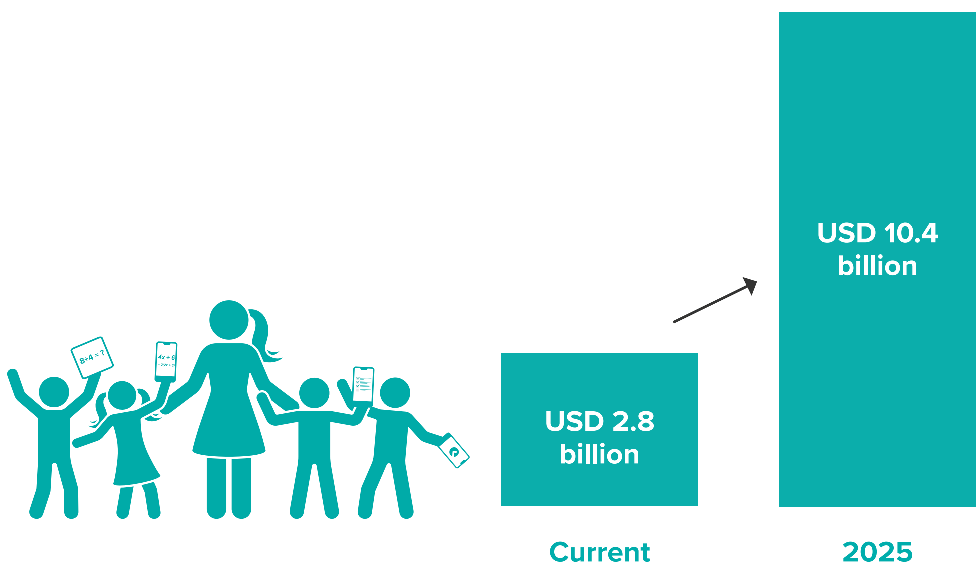
The National ICT Curriculum for teachers by NCERT is focused mainly on ICT literacy and not on ICT enabled pedagogy, which leaves gaps in teachers' ability to integrate ICT with classroom instructional practices (CIET, n.d.). Moreover, there is insufficient teacher coverage and time allocated for ICT training and hands-on practice. Emerging data shows improvement in initiatives relating to teacher capacity, with NCERT launching the NISHTHA program to train 42 lakh teachers out of the 96 lakh present in India. The program also includes a module on the integration of ICT in teaching and learning, however this is currently only available in Hindi and English, making it inaccessible to a large number of teachers in the country (NCERT, 2021).

Parent Capacity

There has been a lack of parental and student awareness and capacity around using technology for education. Despite increased smartphone penetration in the country, awareness of tech delivered learning has been historically low. However, with the COVID-19 pandemic and resulting school closures, we saw that parents played an active role in their children's learning, with even parents who had received less than 5 years of schooling supporting their children at home. The pandemic increased parental awareness and also led to familiarity with using tech for learning. Research has shown (as discussed in the evidence section), that increasing parental engagement is one of the most effective ways in improving learning outcomes. Hence appropriate efforts should be made to harness this awareness and willingness of parents to use tech for learning, and to build their capacity to support children in learning.

Private Ecosystem

The Covid-19 pandemic has provided an impetus to the private EdTech market, with current estimates putting the valuation of the Indian market at USD 2.8 billion, and is expected to grow to USD 10.4 billion by 2025. The leading EdTech companies in India attracted over USD 3 billion in funding between January and August 202, with Byju's receiving the largest share of this investment at USD 1.7 billion, followed by Eruditus, UpGrad and Unacademy (India Briefing, 2022). The EdTech ecosystem has grown rapidly with 9043 EdTech startups; with a corresponding increase also observed in the subscriber base of EdTech firms. Research indicates that the user base has doubled from 45 million to 90 million for the K-12 segment during this period over the last three years (India Briefing, 2022).



Increase in Valuation of the Indian Edtech Market by 2025

While these figures provide optimism in terms of market size, three key market trends are important to note from a perspective of democratizing EdTech for all sections of society:

First, the total worth of the EdTech Market in India in 2019 was estimated to be USD 735 million, out of which the share of the K-12 segment is only ~37% (USD 265 million). Further, the market share of the K-8 segment is only 38% (USD 100.7 million) of the total revenue of the K-12 segment.

This reflects that the K-8 market is still relatively underserviced by EdTech solution providers as a majority of the products are catered towards test prep for the higher grades (within K-12) and the post K-12 segment (Omidyar - Redseer, 2020).

Table 5: EdTech Market Size

Market share as per segment (in terms revenue)	Value in USD (mn)
Grades 1-5	15.9
Grades 6-8	84.8
Grades 9-12	164.3
Total for K-12	265
Post K-12	470
Total market size (K-12 and post-K-12)	**735**

Source: Omidyar-Redseer report on EdTech in India (Kumar et al., 2020)

Second, the EdTech market primarily caters to the high income segments of the Indian population.

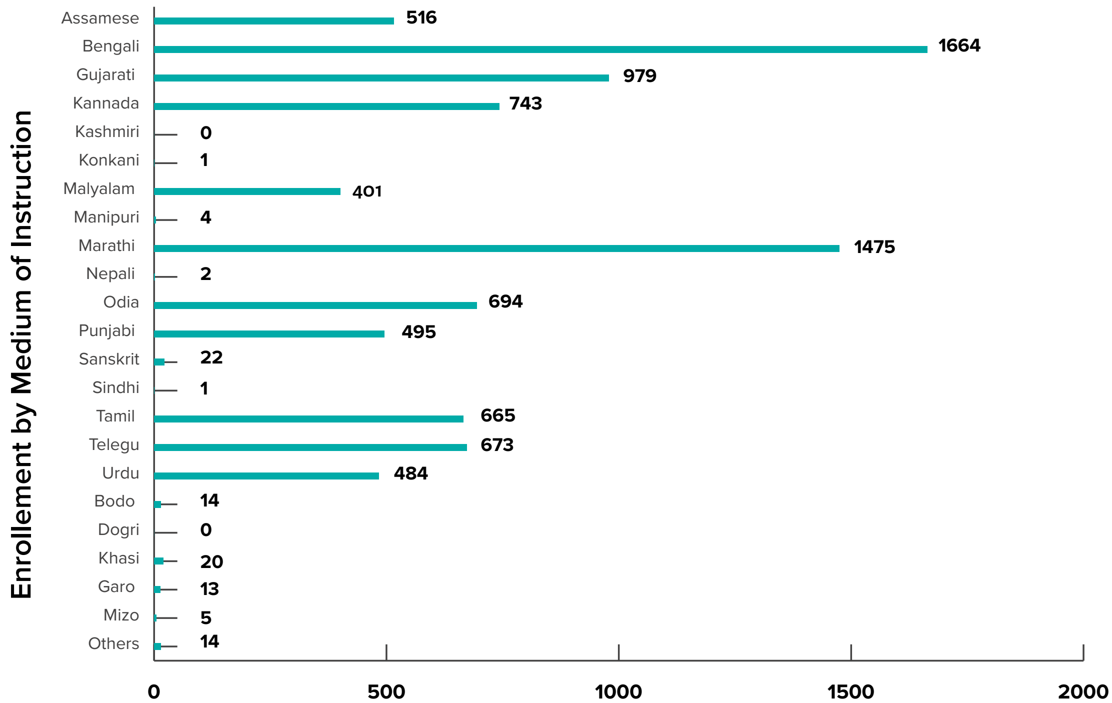
This is reflected in the fact that the average annual cost of the top six funded EdTech solutions, which is approximately ₹ 20,000 per child, is well beyond the paying capacity of most Indian parents (average annual expenditure on education in the rural middle class is ~ ₹ 2,000-4,000 as per Indian Consumer Market projections). A recent study has also indicated that the products that have demonstrated efficacy for students from high-income households cannot be distributed directly to students in a low-income context. The content needs to be contextualized to the learning needs of low-income students and in some cases, be recreated, which implies additional cost of development of products for these companies (Sampson et al., 2019).

Third, there is a dearth of EdTech products/solutions available in local languages.

Sampson et al. (2019) also highlights that the current EdTech companies rarely develop products in local languages which becomes a huge barrier for students primarily learning in the vernacular medium of instruction. Data in Figure 4 suggests that while there is a large proportion of students in English and Hindi medium schools (122 million students), the top five local language medium school students (Bengali, Marathi, Gujarati, Kannada, Oriya) also add up to ~41.61 million; and can potentially serve as a major market for such products. Therefore, it is critical for the EdTech market to be energized towards creating local language content to ensure the maximum reach. The NEP 2020 also highlights the critical importance of education in local languages; specially for the formative years of learning.

Figure 4: State-wise Enrollment by Medium of Instruction, and Number of Students Enrolled (in tens of thousands, 00,000s)

Source: UDISE 2018-19



While this section highlights the current state of the EdTech landscape, including the gaps in the landscape, policies and market; the final section will provide recommendations for policy along the three key EdTech pillars based on evidence and research conducted thus far.

5 Blended Learning During the COVID-19 Pandemic

The COVID-19 pandemic disrupted school education worldwide. On March 16, 2020, the central government ordered all educational institutions in India to shut to contain the spread of COVID-19, which led to the closure of 1.47 million schools impacting 247 million students (UNICEF, 2021) enrolled in primary and secondary grades. Though the school closures came towards the end of the academic calendar in most Indian states, as the lockdown prolonged, the loss of learning became a pressing concern. Given the nature of the pandemic, at-home learning emerged as the only feasible option for continued learning of students. This is reflected in the fact that education responses of central and state governments, and private schools to COVID-19 center around at-home learning. The second wave of the pandemic in April 2021 and continuing school closures brought with it a fresh response, with states exploring models wherein learning could be delivered directly to homes for students across grades.

Government Response to COVID-19 Pandemic

At the start of the first wave, the MoE launched their flagship initiative called PM e-Vidya, which aimed to unify all existing efforts relating to digital, online and on-air education. This covered initiatives such as DIKSHA, an online content library for students and teachers; SWAYAM Prabha, the telecast of high quality educational programs for people without access to the internet; and e-Pathshala, which provides access to e-textbooks (MHRD, June 2020). The second wave of the pandemic led to a renewed emphasis on at-home learning and the MoE issued directives for a 5-phase plan to implement an effective home learning program (MHRD, 2021). This plan ensured every child had access to appropriate textbooks, content identification and curation, physical and digital content dissemination, focus on content engagement, and tracking and assessment of learning outcomes. The MoE also highlighted the importance of increased coordination with states, teacher capacity building and the involvement of parents, local authorities and the community in their most recent national COVID response plan.

At a state-level, every state deployed the use of various digital initiatives including digital classrooms, radio channels, mobile applications and ICT labs (MHRD, June 2020). An on-the-ground picture of the both government and private-school response to the school closures shows us that 80% of children received grade-appropriate textbooks after the closure and 35% of children received other learning materials (ASER, 2021). It was seen that out of the third of children that received other learning materials, 80% of those received the materials on smartphones, primarily through WhatsApp. Thus, WhatsApp emerged as an important distribution channel for school content early on in the pandemic. Doraiswamy et al. (2020) find that states adopted a spectrum of technologies as part of their education response to COVID-19, an approach that can be dubbed 'High tech, low-tech and no-tech'. These technologies ranged from Web-content and Apps (hi-tech), TV and radio based solutions (low tech) to printed materials (no-tech). The technology employed was a function of availability and access to internet and smartphone, and existing digital infrastructure in the state. As a result, the states that had already invested in EdTech solutions were in a better position to respond to the learning crisis. A detailed analysis of best home learning practices across seven Indian states can be found in the Home Learning Playbook produced by Central Square Foundation, Samagra, Boston Consulting Group and Leadership for Equity (CSF et al., 2021).

Learnings from successful At-Home Learning Programs

Despite numerous initiatives by state and central governments, the emphasis on at-home learning is relatively recent in the Indian context. There exist substantial challenges in the design, implementation, and scaling-up of at-home learning programs. These challenges can be classified as technical, demographic, systemic and experiential.

Technical challenges relate to the digital divide, the unequal access to digital infrastructure between urban and rural populations and the existing state infrastructure. Demographic challenges include low levels of parental education, poor digital awareness and cultural norms relating to the use of technology for education. Systemic challenges include low capacity of teachers and local organizations to adapt to online and at-home learning and inadequate mechanisms to accurately assess learning outcomes and progress. Finally, the experiential challenges relate to student engagement levels; the difficulty in replicating the classroom experience online and the issue of incentivising parents and children to continuously engage with digital solutions.

increase in smartphone penetration in rural India in the last four years

Source: ASER, 2021

However, recent trends are promising and suggest greater readiness for online and at-home learning. Data shows that smartphone penetration in rural India has increased by 25% in the last four years (ASER, 2021), allowing more children to access online learning in the form of web-based applications, websites and through WhatsApp. Coupled with this increase in access, there has also been an increase in parental engagement and community support. With schools having been shut, parents became central to children's learning at home; this is reflected in the data which suggests that 75% of children received help either from parents or older siblings at home. Even for children where both parents had less than 5 years of schooling, 55% of them received support at home, showing the value parents give to education (ASER, 2021). Government initiatives like PM e-vidya and DIKSHA provided further impetus to at-home learning models through rapid digitization and dissemination of content. Moreover, inclusion of EdTech solutions in states' education response to the pandemic have created salience and awareness about at-home learning, providing the momentum to explore and implement new home learning solutions.

Blended Learning: Supplementing In-School Learning with At-Home Support

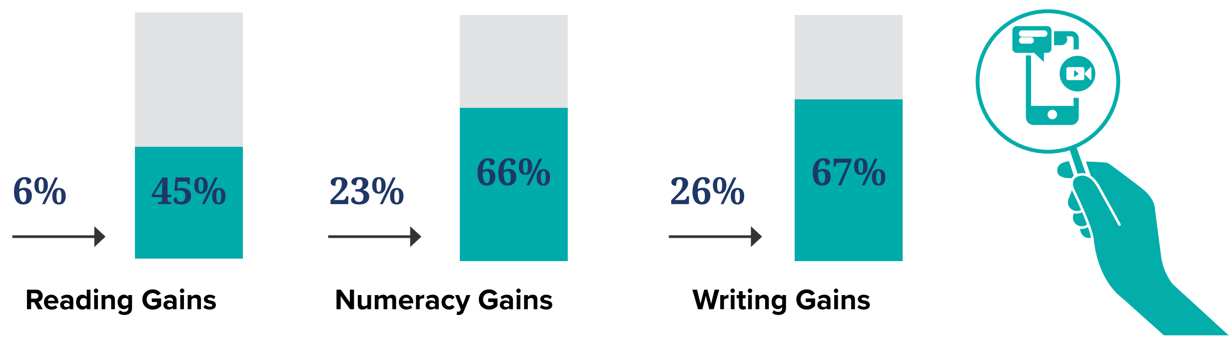
Increased Family Engagement and Support

While at-home learning took a centre stage during the pandemic, it is likely to outlast it. As schools move back to a reopened setting, it will be critical to assess the learning levels of the students to gauge the learning loss and ensure learning recovery.

A report by Azim Premji Foundation found that school closures have led to a widespread phenomenon of 'forgetting' among children, where they have lost foundational abilities or fundamental concepts (Azim Premji Foundation, 2021). Other studies corroborate this by showing that nine out of every 10 children between grades 2-6 have lost at least one language ability and eight out of every 10 have lost one math ability in the last year (Jolad and Kalra, 2021).

As we begin to think about the way forward, even as schools reopen, blended learning will become inevitable, with there being a great need to seamlessly extend learning from home to school, and empower students to problem-solve independently.

By reinforcing concepts taught in the classroom, blended learning and a hybrid mode of study could play an important role in remediation and transition back to school.



The XPrize Foundation analyzed 5 EdTech solutions for ages 7 to 11 in Tanzania over 15 months

This case for blended learning is supported by emerging evidence around the world that shows the efficacy of personalized and digital learning meaningfully impacting learning across grades. The XPrize Foundation analyzed five EdTech solutions and found that they helped improve literacy and numeracy levels among children between the ages of 7 to 11 in Tanzania. Reading improved drastically with over 45% of children being able to read and understand words, up from 6%; in numeracy the ability to do single digit addition and subtraction rose from 23% to 66% (X-Prize, n.d.). In Botswana, a study that evaluated the efficacy of low-tech interventions such as SMS text messages and direct phone calls to support learning at-home, showed that both interventions resulted in cost-effective learning gains. The study showed that there was a 52% decrease in the share of students who could not complete any numerical questions on an ASER test[1], translating into an increase of 24% in average numerical skill (Angrist et al., 2020). Alongside these examples, it will be important to create meaningful evidence around home and blended learning that can guide the ecosystem as it transitions to a new way of learning.

1 The ASER test used in this study was adapted from the face-to-face tests frequently used in India, but specifically for phone use.

In Botswana, a study that evaluated the efficacy of low-tech interventions such as SMS text messages and direct phone calls to support learning at-home, showed that both interventions resulted in cost-effective learning gains.

Due to the pandemic, there has been a systematic effort by the state to invest in the enabling dimensions like creation, curation, and dissemination of high-quality digital educational content, and augmenting teacher capacity through training. Large scale adoption of innovative solutions for continued learning and investments in the enabling environment during the pandemic are likely to have a bearing on how the post-pandemic school education would be conducted. Currently, these interventions have been limited to sporadic efforts to continue learning during school closures.

To sustain these innovative practices as schools reopen, a structured program, aligned with the state's academic work plan and having dedicated budgets can unlock a powerful mechanism to improve learning outcomes. A 'blended' approach which combines in-school instruction with at-home learning to support the child and cater to their individual learning needs is a promising way forward.

6 Evidence on EdTech

Governments interested in adopting EdTech solutions are often faced with the question of which EdTech intervention would be most efficient and equitable and lead to improvements in learning outcomes. In this context, research evidence on the impact of EdTech on learning and other outcomes can be invaluable for informing policy. In the last decade or so, a lot of research evidence has been generated in India on the efficacy of EdTech. In this review we focus on evidence on causal impacts of EdTech generated through Randomized Control Trials (RCTs).

Evidence from India

In this paper, six RCTs conducted to date to evaluate different EdTech programs in India have been considered. These studies provide insights on the following dimension of EdTech:

Personalized Adaptive Learning (PAL)

(Banerjee et al., 2007) and (He et al., 2007) evaluate the effects of Personalized Adaptive Learning (PAL) on student learning outcomes and find large positive effects. One of the interventions in Banerjee et al. (2007) is a computer-assisted learning program implemented in Vadodara, Gujarat wherein grade 4 children from 55 municipal primary schools are offered two hours of shared computer time per week during which they play games, which involve solving Math problems whose level of difficulty is adapted to the child's current level of achievement. This program increased math scores 0.35 SD in the first year, 0.47 SD in the second year and these gains were equitable. However, these large gains fade out one year after leaving the program suggesting that sustaining the gains in the long term might be a challenge.

Muralidharan et al., (2019) evaluate the impacts of a technology-aided instructional program – Mindspark – on learning outcomes. Mindspark benchmarks the initial learning level of every student and dynamically personalizes the material being delivered to match the level and rate of progress made by each individual student. Mindspark is very flexible, it can be delivered in-school, after-schools or used for self-study; it can be deployed through smartphone, tablets or computers; and can be used in both online and offline modes. The researchers evaluated after-school Mindspark centers that aimed to serve students from low-income neighborhoods in Delhi. These centers scheduled 90-minute sessions for six days per week. Each session was divided into 45 minutes of individual self-driven learning on the Mindspark software and 45 minutes of instructional support from a teaching assistant in groups of 12-15 students. 619 students were recruited for the study from public middle schools in Delhi.

The researchers find that student scores in math and Hindi increased by 0.36 SD and 0.22 SD respectively after 4.5 months of access to the Mindspark program. Moreover, the relative gain in learning outcomes was higher for academically-weaker students. The study shows that well designed and implemented technology-enabled learning programs can lead to rapid gains in learning outcomes.

In-School vs Out-of-School

Models for implementation of EdTech; in-school or out-of-school and how it interacts with existing educational inputs are important considerations for any EdTech intervention. Linden (2008) sheds light on these questions by evaluating a computer assisted learning program by Gyan Shala in Gujarat, designed to reinforce student understanding of the course material, in both in-school and out-of-school settings. In the first year, the study was implemented in 23 schools located in two localities, Patdi and Dhrangadra, during the 2004-05 academic year. While in the second year, the study followed the implementation of the program in 37 schools in Ahmedabad and Halol. The study finds that the EdTech intervention is a poor substitute for teacher delivered curriculum when implemented in-school leading to decline in learning by 0.57 SD. However, it is a good compliment to a normal program in an out-of-school setting leading to average gains in learning of 0.28 SD, with largest positive gains accrued by weakest and older students in the class.

Virtual Classrooms

Naik et al. (2016) evaluate a program where satellite-terrestrial technology is used to telecast additional interactive classes in English grammar, Science, and Math to government schools in 1,000 schools in rural Karnataka. Trained teachers deliver the classes making use of video and animation technology, and the topics covered in the classes are part of the school syllabus. The study finds the intervention to have a positive impact on student learning outcomes with scores on math improving by 0.09 SD to 0.27 SD and those in Science improving by 0.11 SD to 0.33 SD for grades 8 and 10.

Moreover, the intervention led to a decrease in the educational attainment gap between socially disadvantaged students and others, and the gains were largest for female students from socially disadvantaged backgrounds.

Digital Assessments

As the NEP shifts the focus to learning outcomes, collecting reliable assessments data becomes an imperative. Singh (2020) evaluates whether tablet-based testing reduces distortions in learning outcomes data which arise due to cheating. The experiment was conducted in Prakasam district of Andhra Pradesh covering all schools in the district with at least five students enrolled in grade 4. A total of 768 schools were assigned for paper-based testing and 1,694 to tablet-based testing. Around 3,500 tablets were used for assessments over a period of 10 days. The study found that paper-based assessments proctored by teachers severely exaggerate achievement, in both private and government schools, but no evidence of such distortion found in tablet-based assessments. Thus, assessment is a key area where EdTech holds great promise in facilitating meaningful learning support.

Infrastructure and connectivity are necessary conditions for adoption of EdTech. Though there have been policy interventions to expand access to digital infrastructure in India, their impact on learning outcomes have not yet been evaluated through impact evaluations.

International Evidence

Infrastructure and Connectivity

Limited access to devices at homes and in schools has been a binding constraint to adoption and use of EdTech. Consequently, there have been many access programs around the world for improving device accessibility. Experimental and quasi-experimental evaluation of access programs show a mixed picture — while these programs improve the outcomes related to device connectivity, their impact on learning outcomes is muted. In fact, experimental evaluation of primary- and secondary-level computer/ device distribution programs in Colombia (Computadores para Educar or Computer for Education), Kenya, and Peru (One Laptop per Child) show no impact on learning outcomes. Some programs even had a negative impact on learning outcomes. These programs were focused on device access only, and other critical aspects, for example, quality content and software, change management, maintenance were not given due importance. On the contrary, a device access program in China significantly improved childrens' mathematics scores. But in this case, the computers that were distributed were reliably equipped with educational software that was actually used by the students. Table 6 compiles the evidence on impact of device access programs.

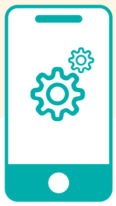
Perhaps a broader learning from these evaluations is that hardware-focused interventions that only provide devices at home or at school seem to have no positive impact on learning outcomes, and need to be accompanied with contextualized and high-quality software, appropriately designed incentives to ensure targeted use and requisite change management.

Table 6: Impact Evaluations of Programs Providing Devices to Students

Country	Study	Grades	Subject	Program	Software Included	Instructor's Role	Effect
Israel	Angrist and Lavy, 2002	4,8	Math, Hebrew	Target student computer ratio of 1:1 in each school	Yes, eductional software	Not specified	Negative/ No effect
Colom-bia	Barrera Osorio and Linden, 2009	3,9	Math, Spanish	15 computers per school	Not specified	Use the computer to support children on basic skills	No effect
Romania	Malamud and Pop-Eleches, 2011	1-12	Math, English, Romanian	One voucher (worth USD 300) towards the purchase of a computer for use at home	Pre-installed and additional provided	Not specified	Large negative effects (≈-0.6 SD)
Peru	Cristia et al., 2012		Math, Spanish	One laptop per student and teacher for use at school and home	39 Education-related applications	Not specified	No effect
China	Mo Swinnen et al., 2013	3	Math, Mandarin	One laptop per student for use at home	Yes, game based math/ mandarin program	Not specified	No effect
Peru	Bueurmann et al., 2015	2	Math, Spanish	Four laptops (one per student) in each grade/section for use at school	32 Education-related applications	Not specified	No effect
Nether-lands	Leuven et al., 2007	8	Math, Dutch	Funding to students for computers and softwares	Not specified	Not specified	Negative effects
England	Machin et al., 2007	6	Math, Science, English	Target student-computer ratio of 1:8 in each primary school and 1:5 in each secondary school	School spent funds for software	No effect	
United States	Fairlie and Robinson, 2013	6-10	Math, English	One computer per child for use at home	Ms windows and office	No	No effect

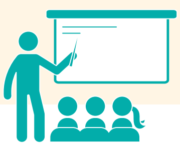
Source: Central Square Foundation, 2021

Software and Content



Computer Aided Learning (CAL)

The computer aided learning (CAL) programs focus on well-defined use of specific software packages designed to develop particular skills in students like improving reading comprehension or math computation. These programs have the potential to personalize learning in three main ways: (i) adaptability, i.e., providing content that is well suited to the current learning needs of student, (ii) providing students with timely and accurate feedback, and (iii) providing teachers with data on students performance that can be used for calibrating their pedagogical approach. The CAL interventions include one or more of the above dynamics. We review the state of evidence on the impact of CAL programs on learning outcomes of students in primary schools, and middle and secondary schools.



Primary Schools

A large number of CAL programs have been designed for students in primary schools (Grade I to IV) and implemented in different countries. Many of these programs substitute teaching input with technology, especially the ones implemented in the classroom. Table 7 summarizes the CAL programs implemented, their key design features and the impact on learning outcomes.

As suggested by Table 7, a large number of CAL programs for primary school students have found limited impact on their learning outcomes, especially in a developed country setting. Similarly, a blended learning program in the US in which teacher instruction was augmented by CAL-based practice routines for students did not have any impact on student learning outcomes.

However, evidence from CAL programs implemented in developing country settings is more positive. Many evaluations of CAL programs in China have found a positive impact on student learning outcomes, especially for Math (Mo et al., 2014; Lai et al., 2015; Mo et al., 2014a).

Most of these CAL programs were after-school interventions where a group of 2-3 students review and practise on the computer what they have learnt in the classroom that week.

These programs were found to be effective both in rural public schools as well as low-income affordable private schools in urban areas, allaying the concerns that CAL programs may not work for children from lower socio-economic backgrounds.

A study from Russia, as shown in Table 7, found that an in-school CAL program for Math and Russian had a positive impact on student learning outcomes.

Table 7: Impact Evaluations of CAL Programs for Primary School Students

Country	Study	Grades	Subject	Student Activity	Intruction Time and Intensity	During (D)/ After (A) School	Findings
US (Urban, sub-urban, rural)	Campuzano et al., 2009	1	English	Blended learning in classroom (teacher explains and students practice using CAL product)	20 Min/ day, twice a week	D	No effect
		1	English	Personalized Self Paced Learning	30 Min/ day, 3 days/ week	D	0.01 SD
		1	English	Blended Learning in classroom	15-30 Min/ day	D	No effect
		1	English	Personalized Self Paced Learning	17-30 Min/ day, 3 days/ week	D	No effect
		4	English	Personalized Self Paced Learning	25 Min/ day, 3+ days/ week	D	No effect
		4	English	Personalized Self Paced Learning (Program provides a 'Learning Path' for each student)	15 Min/ day, 3-5 days/ week	D	0.09 SD
US	Borman et al., 2009	2	English	Self paced learning program for improving oral language comprehension skills	100 Min/ day, 5 days/ week	D	No effect
US	Wise and Olson, 1995	2-5	English	A 3-children team read stories on computer screen. They can hover for meaning of a word they find difficult, and get auditory assistance for comprehension question	420 Min Total, in 30- and 15-Min Sessions	D	Effect size not reported but overall positive effect

Country	Study	Grades	Subject	Student Activity	Intruction Time and Intensity	During (D)/ After (A) School	Findings
China urban APS	Lai, Zhang, Qu et al., 2012	3	Mandarin	A 2-children team played games to practice material taught that week	40 Min/ day, 2 days/ week	A[76]	No effect
China urban APS	Lai, Luo, et al., 2015	3	Math	A 2-children team watched instructional videos and played games to practice material taught that week	40 Min/ day, 2 days/ week, 4 months	A	0.15 SD
China rural	Lai, Zhang, Hu et al., 2013	3, 5	Math	A 2-children team watched instructional videos and played games to practice material taught that week	40 Min/ day, 2 days/ week, 4 months	A	0.14 SD
China rural	Mo, Zhang, Wang, et al., 2014	3, 5	Math	A 2-children team watched instructional videos and played games to practice material taught that week	40-Min/ day, 2 days/ week, 1.5 Years	A	0.25 SD
China rural	Mo, Zhang, Luo et al., 2014	3, 5	Math	A 2-children team watched instructional videos and played games to practice material taught that week	40 Min/ day, 2 days/ week, 1 year	D[77]	0.18 SD
China	Mo, Bai et al., 2016	5	English[78]	Treatment 1: blended learning Treatment 2: videos and games	40 Min/ day, 2 days/ week	A	T1: 0.16 SD T2:0.09 SD
Equador	Carrillo et al., 2011	3-5	Math, Spanish	Personalized curriculum based on screening test	180 Min/ week	D	No effect

Country	Study	Grades	Subject	Student Activity	Intruction Time and Intensity	During (D)/ After (A) School	Findings
US	Rouse and Kruger, 2004	4-6	English	Begin at the basic level in the game, and progress to more advanced levels (in total 5-7 games)	90-100 Min/ day, 5 days/ week	A	No effect
Ghana, rural	Johnston and Ksoll, 2017	2-5	Math, English	Remote interactive lessons and students could communicate in real time with their remote teachers	1 hr/ week for each of Math and English, 2 years	D	0.24 SD
Russia	Bettinger et al., 2020	3	Math, Russian	Treatment 1: 45 mins CAL, Treatment 2: 90 mins CAL, Control	1 session/ week, 5 months	D	T1: Math: 0.109, Russian: 0.068, T2: Math: 0.098, Russian: -0.005
China, rural	Ma et al., 2020	4-6	Math	T1: CAL gamified program, T2: Same content without CAL Control	40 mins/ week, 7 months	A	effect due to additional time only, not due to CAL

Source: Central Square Foundation, 2021

Overall, the historic evidence suggests that: (a) after-school CAL programs are more effective than in-school programs, (b) CAL programs might be more effective in improving math skills than language/ reading skills, and (c) intervention design plays a key role in the effectiveness of the program.

However, recently new evidence has emerged to support the improvement of learning outcomes in both literacy and numeracy for early learners. Through the Global learning XPRIZE challenge, five finalist teams participated in an intensive 15-month field test of their softwares in Tanga region of Tanzania. The finalist teams included CCI, Chimple, Kitkit School, onebillion, and RoboTutor. The field test took place between December 2017 and March 2019 and involved distribution of software to 2,700 children, aged 7 to 11, across 170 villages in the Tanga region of Tanzania. These children were divided into five treatment groups and one control group. Each treatment group used tablets with the learning software developed by one of the five Global Learning XPRIZE finalist teams, while the control group did not use any tablets. The field test results found learning gains in reading, numeracy, and writing with effect sizes ranging from 0.44 to 0.59 SD (X-Prize, n.d.).

Another recent study of the impact of a standardized CAL program has been implemented in Kenya. It was seen that Kenyan students who won a lottery for 2-year scholarships to attend schools that employed a highly structured and standardized approach to pedagogy and school management learned more than students who applied for, but did not win a scholarship. These schools, called Bridge schools, standardize lessons across all grades through centrally developed and highly detailed lesson guides that are delivered to teachers using tablet computers. The study saw that primary school students enrolled in these schools for two years gained approximately 0.89 extra years of schooling, while in pre-primary grades students gained around 1.48 years of additional schooling (Gray-Lobe et al., 2022). The test score effects in this study are among the largest in international education literature and have important implications for policy decisions made to explore the use of technology and standardization of learning.

Middle and Secondary Schools

Often, CAL programs are encouraged for Middle and Secondary school students (grade 6 to 10) for associated improvement in computer-skills which may be valuable in the labour market. However, there are only a limited number of evaluations that study the impact of CAL programs on learning outcomes for students in Grades 6 to 10. Table 8 summarizes these research studies.

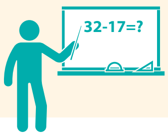
These studies are a mixed bag. In the US, a self-paced program for improving English oral language comprehension skills for Grade 7 students did not have any impact; whereas, a self-paced Maths program for Grade 8-10 improved Maths scores by 0.17 SD. However, another CAL program for Maths for Grade 6 did not find any impact on Math scores of students. An intensive CAL intervention for Mathematics for Grade 7 and 8 in the US finds a large positive impact of 0.56 SD to 0.63 SD. Relative to primary grades, the impact of blended learning programs on learning outcomes for students in Grades 6 to 10 is promising. Two Blended Learning programs for Math from the US and Pakistan show very large effects of 0.29 SD and 0.30 SD respectively.

Table 8: Impact Evaluations of CAL Programs for Middle and Secondary School Students

Country	Study	Grades	Subject	Student Activity	Intruction Time and Intensity	During (D)/ After (A) School	Findings
US (urba, suburba, rural)	Campuzano et al.,	6	Math	Personalized learning (tutorial, practice, and assessment opportunities)	2 hours/week, 25 weeks	D	No effect
US	Borman et al., 2009	7	English	Self paced program for improving oral language comprehension skills	100 min./day, 5 days/ week	D	No effect
US	Roschelle et al., 2010	7-8	Math	Software based math curriculum intervention	Daily, 2-3 weeks, 1-2 years	D	0.56 SD- 0.63 SD
Pakistan	Beg et al., 2019	8	Math, Social Science	Blended learning using digital classrooms	29 hours of content spread over the entire year	D	0.3 SD, after 4 months
US	Morgan and Ritter, 2002	9	Math	Blended Learning - teachers facilitate student learning and guide students through discussions on applied and acquired information	all algebra classes in school, 1 year	D	0.29 SD
US	Barrow et al., 2009	8,9	Math	Self paced personalized learning	all algebra classes in school, 1 year	D	0.17 SD
Mexico rural	Navarro-Sola, 2019	6-10	All Subjects	Televized lesson followed by discussion with homework	15 mins (TV) 35 mins (in class exercise) all year	D	1 additional year of attainment (0.12 SD)

Source: Central Square Foundation, 2021

Capacity Building (Individual and Institutional)



Teacher Capacity

Teachers play an important role in the learning process of students. This also extends to EdTech where effectively incorporating and integrating technology into classroom instruction is contingent on the teacher. Qualitative studies suggest that teachers face a host of barriers in implementing technology in their classrooms, and that teacher learning and professional development are fundamental to the effective integration of technology in teaching (Mouza, 2009; Kopcha, 2012; Kelly, 2015). COVID-19 induced school closures and move to online learning have brought to fore the importance of tech-preparedness of the teachers. However, there is a gap in the literature with respect to rigorous impact evaluations of the EdTech training programs on teachers' capacity. Most studies to date evaluate the impact of EdTech solutions on student outcomes; if they have a teacher training component, its purpose is to facilitate the effective implementation of the Edtech solution for student learning and not specifically to augment teacher capacity. Table 9 provides a list of such studies.

Parental Engagement

Parent's engagement in the learning activities of their children is one of the most effective ways to increase child educational outcomes (Levine et al., 2010; Price, 2010; Sénéchal and LeFevre, 2002). However, cognitive and resource constraints faced by parents could limit their ability to effectively engage with their children's learning activities. These constraints may affect how parents value educational investments in their children and also the day-to-day decisions about the homework, assignments, and test preparation of children. This is particularly true for disadvantaged households. Recently, technology-based interventions have evolved that aim to improve the quality and quantity of time spent by parents with children in learning activities. Most of these interventions depend upon sending text message reminders to parents. Six of these interventions have been evaluated using RCTs and all found positive results. The Table 10 below summarizes these evaluations. In the context of COVID-19 induced school disruptions, Angrist et al (2020) study the strategies to minimize the effect of the pandemic on education outcomes. As also mentioned in the blended learning section of this paper, through an RCT in Botswana, the researchers evaluated two low-technology interventions to substitute schooling during this period: SMS text messages and direct phone calls for a sample of 4,500 families with primary-school aged children. They find promising results which suggest that both interventions lead to learning gains of 0.16 to 0.29 SD. As evidence suggests, technology-based interventions for parental engagement hold promise.

Table 9: Evaluations that had Teacher Training Component

Country	Study	Teacher training example
Israel	Angrist and Lavy, 2002	Training for teacher to integrate computers into teaching
Colombia	Barrera-Osorio and Linden, 2009	20-month training for teachers, provided by local university
Romania	Malamud and Pop-Eleches, 2011	530 multimedia lessons on the use of computers for educational purposes of students
Peru	Cristia et al., 2012	40-hour training aimed at facilitating the use of laptops for pedagogical purposes
England	Machin et al., 2007	In-service training for teachers and school librarians
China, rural	Mo, Zhang, Wang et al., 2014	Two-day mandatory training for B) making sure that the cal curriculum in each session was matched to the curriculum being taught in the students' math class C) managing the cal classrooms D) troubleshooting when stduents experienced operational difficulty E) taking care of the cal desktops and seek support
India	A. Bannerjee et al., 2007	Computer instructors from local community

Source: Central Square Foundation, 2021

Table 10: Evaluations of Edtech Interventions for Parental Engagement

Country	Study	Grades	Parents Engagement Strategy	Effect
Brazil	Cunha et al., 2017	9	Weekly text message on attendance	0.09 SD
US	York and Loeb, 2014	Pre-school	3 messages per week with tips and literary activites (small and easy tasks) not what parents do anyway	0.29 SD
US	Mayer et al., 2015	Pre-school	Daily text message reminders to read to the kids children books loaded on a tablet provided by schools, parents report back to the progress on tablet	1 SD
US	Doss et al., 2017	Kindergarten	Personalized and differentiated text messages matching child's level	50% More likely to read at a higher level
US	Hurwitz et al., 2015	Kindergarten	Parents survey after sending daily text message with a variety of learning activity	Parent engagement increased
US	Kraft and Monti-Nussbaum, 2017	1-4	Text messages with tips during summer break	0.21-0.29 SD
US	Bergman, 2015	6-10	Text/class when class or assignment is missed	0.20 SD
Chile	Berlinski et al., 2016	6-10	Text/class when class or assignment is missed	0.09 SD, less bad behavior
US	Bergman et al., 2018	6-10	Weekly texts with number of missed class or assignment or if scoring is below average	0.10 SD or 0.26 SD (for poor performing students)
US Urban	Balue et al., 2016	9-10	Text when school missed	No effect`
US	Kraft and Dougherty, 2013	6-10	Text, one phone call from teacher	Homework completion increased by 40%
East Malawi	Dizon-Ross, 2019	2-6	Walking through children's report cards during household visits	Less education parents engage more in children's learning

Source: Central Square Foundation, 2021

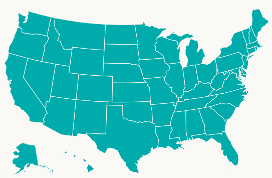
7 EdTech Policies: Global Perspectives

With a good sense of the state of evidence on EdTech, this section analyzes the EdTech policies of different countries and their approach towards implementation of these policies for school education. Countries of focus are Singapore, the United States of America (USA), China, and Indonesia, and are chosen for their relevance to the Indian context. Singapore was one of the earliest adopters of a comprehensive EdTech policy globally. The Global Competitiveness Report 2001-2002 recognized the EdTech achievements in Singapore are second in the world after Finland. The United States has two well-laid out EdTech policies and, in addition, the US has also taken the lead in integrating Edtech in teaching and learning practices. China, comparable to India in terms of its population, has enabled a large proportion of its schools with EdTech programs in a short span of time . And lastly, Indonesia as its education system shares a lot of parallels with India. For example, education in Indonesia is compulsory and provided free of charge at public schools from grades one to nine, including six years of elementary education and three years of junior secondary education.

Singapore

Singapore embraced EdTech in 1997 and has been a pioneer in its adoption to bolster education at schools and homes across grades. The Ministry of Education, Singapore(MoE-S) has introduced four EdTech Policy Master Plans (MP) so far with clear goals for meaningfully integrating technology in education - MP1:1997 to 2002, MP2: 2003 to 2008, MP3: 2009 to 2015, and MP4: 2015, and beyond. The first plan-MP1 had a budget of S$2billion, which was almost S$650 per student in Singapore. By 1990, all schools in Singapore had a computer for their information management and by 1996, teachers were trained to use teaching and learning software. Starting in 1997, the four master plans were set into motion and benefit the 428,773 students and 32,680 teachers across 356 schools today (Tin, 2008) (MoE-Singapore, n.d.). ICT has been a key enabler in accelerating Singapore's economic development.

United States



The US is the world's largest EdTech market and has been at the forefront of integrating EdTech in teaching and learning. EdTech in the US has been spurred by a clear vision of integrating Edtech into education, a burgeoning product market, and the National Education Technology Plan (NETP)- is the flagship educational technology policy document for the United States. It was first released in 1996 and has been updated every five years since then. The latest plan was released in 2016, on the lines of the 2015 'Every Student Succeeds Act' (ESSA). The vision of EdTech in these policies emphasize on its potential for democratising education by bringing equity in learning. As per the National Council for Educational Statistics (NCES) data, the mandatory K-12 structure in the US comprises 1,30,930 schools divided into 3 levels of education (primary/elementary, junior/middle and high school). For its 3.2 million teachers and 58.7 million students, the federal agencies spent a total of USD 708 billion in 2016-17 (NCES, n.d.).

China

In China, the education system is divided into three categories: basic, higher, and adult education. By law, each child must complete nine years of compulsory education from primary school (six years) to junior secondary school (three years). In 2018, there were 213,800 schools for compulsory education across the country with 9.73 million teachers and 400 million students. Over the past two decades, the Chinese government has created and implemented multiple policies and initiatives across the country to ensure effective and equitable access and usage of ICT in primary and secondary education (Omidyar Network 2019). Furthermore, recognizing that the development of high-quality resources, content, and pedagogies lagged behind the development of ICT infrastructure in the 2000s and the early 2010s, China has strengthened the emphasis on the development of the former over the past decade (Abbey et al. 2019). Educational reform has prompted the creation of five-minute classes, massive open online courses, micro-lectures, and other digital resources (Jiao et al. 2014), which are used in various combinations to assist students based on their education level. In 2018, 96.5% of primary school teachers had an associate degree or higher and the average number of instructional computers per 100 students in primary schools increased from 10.5 to 11.1, and that in junior high schools rose from 14.8 to 15.2 compared to last year. As per the Ministry of Education's statistics for 2018, 97.8% of primary schools had internet access. The urban-rural divide in internet access is negligible- 98.3% of primary schools in urban areas and 97.7% primary schools in rural areas have internet access. Similarly, 99% of junior high schools have access to the internet.

Indonesia

Indonesia has the fourth largest education system in the world, comprising over 50 million children, 3 million teachers and 300,000 schools (7% of primary schools are private, 56% at the junior-secondary level and 67% at the senior-secondary level) (ASEAN, 2014). Out of these schools, approximately 84% are under the Ministry of Education and Culture (MoEC), while the remaining 16% fall under the Ministry of Religious Affairs (MoRA). As the Indonesian Archipelago consists of more than 17,000 islands, the education system is highly decentralized, and a considerable amount of power resides within provinces and districts to use budgets for their respective localized contexts. That said, the school system is still centrally steered by the MoEC, which is responsible for curriculum, planning, implementation and monitoring of educational practices in the country. In this system, Indonesian schools are accountable to several different institutions as they are operated by regional governments but regulated at the federal level. School curricula differentiate schools as 'regular' schools or madrasah (Islamic) schools. Regular schools are operated by the Ministry of National Education (MoNE), while madrasas are under the governance of the MoRA. This complex network of authoritative bodies in the education system requires EdTech companies intending to scale in Indonesia to successfully communicate and negotiate with many different stakeholders — central- and regional-level government, three ministries (noted above, along with the Ministry for Research and Technology, which is responsible for higher education institutions), and the BAN-SM (Badan Akreditasi Nasional Sekolah Madrasah, n.d.) — while also accounting for the different needs of regular vs. madrasah and public vs. private schools.

Here we describe the key learnings for India from the experience of these countries in designing and implementing effective EdTech policies.

Learnings for India

1 Infrastructure & Connectivity

- The primary focus of Singapore's EdTech Master Plan 1 (1997-2002) was to equip all the schools with devices, internet, and support to adopt EdTech.
- NETP in the US recommends procurement through leasing and cooperative purchasing of devices. It has declared the internet as an essential resource and private players are encouraged to set-up internet connections at highly subsidized costs in rural areas in students' homes and schools.
- Indonesia is extensively investing in its internet infrastructure to enable access across all its citizens. Through projects like Palapa Ring project, construction of a massive, nationwide internet network using fiber-optic wires that connects capitals of over 500 districts has been completed and will help bridge the digital divide in the country.

2 Software & Content

- Singapore setup baseline standards for ability-driven learning outcomes for its students. Thus, national and state initiatives shouldn't just target providing access to infrastructure but also target learning goals of students.
- The National Educational Resource Public Service Platform in China is an open and public platform operationalized in late 2012 that aims to host all digital educational resources on one database by 2020 (Abbey et al. 2019). This can serve as a learning model for the National Digital Education Architecture creation for India.

- The 'Prestigious Online School Classroom' is a program in China through which high-quality schools share their educational resources – via school networks, online courses, etc. – with schools across the region or the country (ibid.).

- China also has a framework for regulating the EdTech content provided by the private sector for the purpose of quality assurance and contextualization to needs of the local population.

3 Capacity

- The evolution of Pustekkom in Indonesia from serving as a content supplier in 1978 to becoming the central government's chief governing body for ICT usage in education in 2008, can serve as a learning for India's NETF and provide a roadmap for successful implementation in the coming years.

- The US EdTech policy lays emphasis on continuous capacity building of educators. Programs like Teach to Lead[1] provide a platform for teacher-leaders and allies across the country (and around the world) to create and expand on ideas (OET, n.d.).

- The NETP encourages shared responsibility of teachers and school leaders for the success of EdTech programs, giving teachers the independence to evaluate CAL programs that are best suited to their needs.

- China has always ensured that both students and teachers have a collective understanding and experience of using ICT in school, and learned best practices for the same (Miao 2008). The MoE-C organizes and implements new rounds of teacher training, integrates local projects and resources, constructs a teacher selection platform, and promotes training aligned with the needs of teachers.

The learnings from EdTech policies and corresponding implementation experiences from Singapore, the United States, China, and Indonesia can be instructive for India in development of its own EdTech policies

1 A joint program of the National Board for Professional Teaching Standards, ASCD, and the U.S. Department of Education, aims to advance student outcomes by expanding opportunities for teacher leadership, particularly opportunities that allow teachers to stay in the classroom (Teach to Lead, n.d.).

8 Recommendations

1. States should adopt an EdTech planning framework to design effective strategies for both in-school and at-home learning

Given that the state lies at the center of all stakeholders in a given environment, it has the potential to play a key role in the EdTech ecosystem. The SABER-ICT policy framework (Truncano, 2016) was drafted to help policymakers in effective design and implementation of ICT schemes; while initially imagined for developed nations, contextualizing this framework for India will enable states to design effective EdTech strategies for both in-school and at-home learning. In order to implement a systematic and evidence informed ICT strategy, policymakers should:

- Analyze EdTech readiness by conducting a detailed baseline of existing hardware, software and capacity of the state.
- Conduct a needs assessment to identify the major challenges faced by students and teachers and ascertain how EdTech can play a catalytic role.
- Ascertain the budgetary implications and feasibility of different EdTech archetypes.
- Design a holistic EdTech roadmap and action plan.

- Identify and establish a suitable demonstration site as proof concept; within this site policymakers should undertake - careful selection of schools/districts, procurement of hardware and software, capacity building of individuals and institutions and development of a monitoring framework for the project. Based on the learning from the demonstration site, the state can then start expanding the EdTech intervention to other districts/schools.

This framework is depicted in the schematic diagram below and discussed in detail in the Appendix.

Table 11: State Framework for EdTech in School and At-Home

State Framework for EdTech In-School & At-Home

Analyze EdTech Readiness of a State

Needs Assessement to Identify the Program Intervention

Design EdTech Roadmap for 3-5 years & Action Plan for Upcoming Year

PHASE I - Proof of Concept

Selection of districts & schools	Fit to purpose EdTech procurement *High quality contexualized content, relevant software, procurement model*	Capacity building towards sustainability	Monitoring & evaluation

Ascertain Budgetary Requirements for Implementation of EdTech

PHASE II - Scale the Program

Source: Central Square Foundation, 2021

2. Build salience around blended learning, and establish dedicated teams and budgets for the same to unlock learning outcomes

Given the learning loss that has occurred during the pandemic, it is recommended for at-home learning to continue to support and augment the instruction that is taking place in schools. This blended learning approach, where concepts taught in school are reinforced at home, will ensure that all children are given ample opportunity to remediate, practice and compensate for learning loss. Technology can play a pivotal role in a blended learning approach, as innovations both locally and globally have shown the variety of ways in which technology can be leveraged. To sustain these innovative practices as schools reopen, a structured program, aligned with the state's academic work plan and having dedicated budgets can unlock a powerful mechanism to improve learning outcomes. The budgets can be dedicated to building engagement and awareness through posters, campaigns, small rewards, community volunteers, etc. A dedicated team at the state-level to monitor these efforts in the first few years can be identified to ensure sustained intervention.

3. In order to leverage technology for achieving FLN by 2025, as envisioned by NEP 2020, prioritize integrated schools for expanding digital and physical infrastructure through ICT@Schools budgets

As per UDISE 2016-17, the current hardware penetration in schools is limited (refer to Figure 1). For leveraging EdTech, digital and physical infrastructure needs to be expanded significantly. Given the budget constraints, this expansion would inadvertently require some prioritization. The prioritization for spending ICT@Schools budgets can be systematic, and it is recommended that integrated schools, with primary and secondary grades be prioritized over others because:

- They are likely to benefit students for a longer duration, as they age within the school;
- Integrated schools are more likely to have basic infrastructure such as rooms, electricity, furniture etc. and other enabling conditions for an effective ICT implementation, compared to smaller schools, and
- States will have the flexibility to implement Edtech solutions in lower grades. This is relevant in the context of the NEP 2020, which has called out the need to prioritize Foundational Literacy and Numeracy in mission mode. Moreover, evidence suggests that disparity in overall learning outcomes starts in early grades and exacerbates over time (Muralidharan & Zieleniak, 2013). Foundational skills of literacy and numeracy are often binding constraints to higher order skills and ICT is proven to deliver a particularly high return on investment for younger grades (USAID, 2018).

This prioritization of integrated schools should also be considered in the context of emphasis on school consolidation by the NEP 2020.

A suggested prioritization is laid out below:
P1: Schools with grades 1-12, 1-10;
P2: Schools with grades 1-8;
P3: Schools with grades 6-8, 6-10, 6-12;
P4: Schools with grades 9-10, 9-12, 11-12;
P5: Schools with grades 1-5

4. Improve the capacity of the ecosystem for successful implementation and adoption of EdTech in schools and at homes

Institutional Capacity

Creation of Central and State Institutions for EdTech Implementation

1. At Center

- Establishing the National Education Technology Forum (as mentioned in the NEP 202), a central government institution, would lead to the creation and direction of a national vision for EdTech. In addition to the roles and responsibilities defined for the NETF in the NEP, the key responsibilities of such an institution may also include designing master plans that clearly state the goals and implementation plan for the next few years. Considering the variation in individual states' capacity of implementing EdTech currently, these plans could be different for champion, progressing, and aspiring EdTech states.
- Central (and consequently, state) capacity should be built to procure all the essential components of an effective ICT program including hardware, software and services. Given the variety of use cases of EdTech it is proposed that standardized formats of RFPs be available as public goods for different states to contextualize as per their requirements.

2. At State-Level

- State governments can establish a Technical support Unit (TSU) as a division of the state school education department. Such TSUs will have the legal, technical and research capabilities required to implement EdTech effectively in states. The TSU can also support the States in creating state-specific master plans as per the guidelines given by NETF.

- States should be supported in identifying and selecting the right EdTech software through standardized toolkits like EdTech Tulna, which will reduce ambiguity and information asymmetry in software selection. This will help stakeholders make informed decisions on what will be most effective in their own contexts.

- Learnings from different state systems in experimenting with forms of procurement including centralized / decentralized, bundled / unbundled should be widely shared to build the capacity of all stakeholders.

Individual Capacity

Teachers

Given that the National ICT Curriculum and training program has limited scope, there is a need for a structured ICT capacity building program which provides periodic and holistic training to all teachers in the domains of ICT literacy, ICT curriculum and ICT enabled pedagogy. Building this capacity can be one of the mandates of the TSUs.

1. In-Service Teachers

Teachers should be comfortable in implementing EdTech programs with students. While the first step towards this has been taken via the ICT module in NISHTHA, there can be further training deployed to ensure meaningful uptake of EdTech. A baseline level of EdTech capacity of teachers is a prerequisite before launching EdTech Programs in schools and their training should ensure those skills. Credentials for EdTech skills after their training can be a good encouragement for teachers' professional growth. Number of teachers in schools acquiring these credentials should be reported in UDISE to track the progress of capacity building measures nation-wide. Awards and recognition schemes for innovation using EdTech in classrooms, exemplary lesson plans on DIKSHA, developing 21st century skills in students, etc. should also be continued and strengthened.

2. Pre-Service Teachers

District Institute for Education and Training (DIET) students should also go through mandatory courses on EdTech where they are prepared for conducting different kinds of EdTech programs, digital assessments, etc. They should be trained on how to use students' learning outcomes data so that they can take advantage of dashboards that come from different EdTech programs.

School Leaders

School leaders should be provided with capacity building measures for EdTech. This would enable them to facilitate technology adoption at schools along with the teachers. The responsibility to ensure functioning of EdTech labs in the schools, and oversee an efficient process to work with system integrators in case of issues should lie with the school leaders

Field Staff

In addition to the teachers, the field staff including the block and cluster level officers should also be provided ICT training as a part of their regular training. Block and cluster resource centers should also be provided with classroom observation and data collection tools which include components of ICT skills and should be given adequate training on usage of these tools as well.

Parents

Capacity of parents in terms of their knowledge and awareness mediates how effectively they can engage with the learning activities of their children. Given that parents are a key stakeholder in the learning journey of children, specially in the foundational years, it is critical for states to undertake mass awareness campaigns to encourage increased and meaningful parental participation in learning activities at homes.

5. Improving accountability of the system for efficient and effective implementation of EdTech policies and initiatives

- Government investment in building state capacity to procure hardware and create robust data gathering and management tools would lead to the effective management of hardware vendors and hold them accountable. Correspondingly, the governments should ensure timeliness of payments to vendors as payment delays can hinder private participation especially for small and medium size vendors (World Bank, 2017).
- Governments may consider designing an output-based procurement contract, with strict service level agreements (SLAs) tied to payment terms. SLAs have the potential to keep the vendor accountable for timely deployment and continuous maintenance for a fixed term. The performance management metrics for these services should be clearly defined.
- Periodic reviews of the utilization of budgets allocated under the ICT@schools scheme to different states, combined with a review of appropriate action plans for utilization may also drive effective procurement and deployment.
- Current ICT policies need greater clarity when it comes to procurement processes of EdTech software. Dedicated budgets and transparent processes need to be laid out to ensure that high-quality and robust software is adopted by the state governments, and states need support in identifying high-quality contextualized software and allocating a value to it.

- All EdTech interventions deployed should have a layer of evaluation built in to assess the impact of the investments made. This evaluation will also allow interventions to rapidly iterate their product and program in order to make improvements that can positively impact beneficiaries.

6. Build innovative models to ensure access to devices by children and design the right incentives for effective use of devices for learning

Key learnings from device distribution programs indicate that devices should necessarily meet minimum specifications needed to run EdTech apps and also be easy to maintain. Moreover, while standard hardware is a necessary condition for such a program, program design features, including making high-quality content available, incentivizing targeted usage towards education, and ensuring adequate change management among parents and teachers are critical for the success of device distribution programs. Hence, these factors should be considered by states and centre while designing any such program going forward.

Going forward, we remain optimistic about the power of technology to eliminate the borders and walls of the classroom so that every child has access to the best quality education, both in school and at home. The synergistic actions of governments, for- and not-for-profit EdTech companies, academics, teachers and parents can be transformational and help us reimagine traditional ways of teaching and learning to positively impact the learning outcomes of our children (Gupta et. al., 2022).

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Appendix

EdTech Planning Framework for States

The state occupies a unique position in the EdTech ecosystem. By virtue of being at the confluence of all the stakeholders of the ecosystem, the state is the key interlocutor and has responsibilities ranging from planning and financing to implementation and monitoring of EdTech schemes and initiatives. To help policymakers in effective design and implementation of ICT schemes, the World Bank developed the SABER-ICT policy framework (Truncano, 2016). While this framework draws largely from the examples of developed nations, which face different circumstances and preexisting conditions, it can be contextualized to the India context and help in drafting and evaluating key ICT policies of both the central and the state governments. This section is an attempt to adapt the SABER-ICT policy framework for India which will enable the states to design effective EdTech strategies for both in-school and at-home learning.

Studying budget trends indicates that there is a limited amount of ICT funding allocated to States for ubiquitous coverage (in terms of number of schools covered in a state and per school funding). Therefore, it is critical for the States/UTs to prioritize challenges which EdTech can help address and accordingly conduct needs assessment, ascertain budgetary requirements and appropriately plan for PAB applications.

To do so systematically and in an evidence informed way, states can refer to the following ICT Framework for creating a holistic EdTech roadmap including program design, budgets, procurement for successful execution of EdTech both in school and for at-home learning.

Analyze the EdTech Readiness of a State

The first step of the planning process is to know the current state of affairs. Conducting a detailed baseline of the existing hardware, software, and teacher capacity of the state is critical to build the foundations for effective EdTech solutions, both in school and at home, as seen during the COVID-19 pandemic. This can be done using existing data sources like UDISE+, state specific portals, along with conducting stakeholder interviews. In addition, a sample survey through school visits to estimate the actual status of EdTech infrastructure and usage would be helpful for data validation. The data points listed in the 'Key Parameters' section of this Appendix can help in indicating the state's current status and readiness for in-school and at-home learning programs. While conducting this baseline, it would be useful to collect data on the status of Service Level Agreements and understand if they are met by the vendors across the three pillars of hardware, software, and capacity.

Additionally, it would be important to ensure that the baseline sample is representative of administrative, geographic and demographic divisions (eg. tribal areas, different language, etc.) of the state, as Edtech programs may need to be customized in different districts based on the access to digital infrastructure and connectivity.

Conduct a Needs Assessment to Identify the Program Intervention

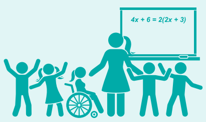
In parallel, states may conduct a detailed diagnostic using primary and secondary research (using NAS, ASER, and State level data) to identify major challenges faced by students and teachers, and identify how Edtech can play a catalytic role in solving these challenges.
For example:

- if a state observes consistently low learning levels for children in grades 6 to 8 in NAS, the state may consider prioritising remediation by leveraging PAL labs for such grades.
- If a state wants to focus on reversing the learning loss due to prolonged school closures in the pandemic, the state may prioritize home learning models appropriately for the purposes for remediation, revision or homework.

Similarly, if the State observes that the teachers are scoring low in ICT modules of teacher training (like NISHTHA), the State may prioritize dedicated ICT training for teachers to leverage technology for effective pedagogical techniques, assessments, etc.

Ascertain Budgetary Implications for Different EdTech Archetypes

Based on the EdTech readiness of the State, it may consider EdTech archetypes that meet its needs. Cost implications of two prevailing EdTech archetypes are highlighted below, given the fiscal availability under Samagra Shiksha guidelines mentioned in the Budgetary Trends section earlier.



1. In-school solutions

1:1 Solutions

Solutions which cater to one student at a time, imparting personalized instruction usually in the form of an ICT Lab with computers, tablets, laptops etc. For example, Personalized Adaptive Learning labs with : 25 laptops (including peripherals) can be accommodated within the stipulated budget depending on the type of hardware needed. As the number of students increases, there would be a need to increase the number of terminals proportionately.

1:Many Solutions

Solutions which serve as an instructional aid for teachers, in the form of a digital classroom or smart classroom via a projector, TV or smartboard. For example, 9-10 projectors along with furniture can be purchased for implementing 1:many solutions under the stipulated ICT budget. Additionally two smart classrooms per school can be set up where ICT budgets have been available for five years.

2. Blended solutions

1:1 Solutions

Solutions providing personalized instruction via a mobile or tab at home directly to children. For example, a prevailing form of such a solution is an assessment chatbot, currently being used by multiple states (e.g., Madhya Pradesh, Maharashtra, Himachal Pradesh) wherein students are assessed and provided remediation over whatsapp.

1:Many Solutions

Solutions which provide learning material in the form of videos, audio notes, worksheets, and handbooks to whatsapp groups of parents and teachers. For example, under Mission Prerna, the Uttar Pradesh government is providing online learning material on a large scale to students in grades 1, 2 and 3 leveraging WhatsApp groups of parents and teachers.

Design a Holistic EdTech Roadmap and Action Plan

Once the States have a broad understanding of the budgetary implications of EdTech Archetypes, they may design a holistic Edtech roadmap for 3 to 5 years as per the unique context. Further, States may devise a detailed action plan for the upcoming year based on the budget estimates. As EdTech interventions have high financial implications on the State and need other enabling conditions to deliver the desired result , there is a need to consider a phased planning approach for EdTech deployment across the State.

Establish Demonstration Sites

In order to ensure optimal use of the EdTech budget in the upcoming year and use EdTech efficiently, states may need to prioritize in-school interventions, at-home interventions or a combination or both, based on state requirements in a few demonstration sites.

A. Selection of Demonstration Sites

1. District Selection

Based on the district-wise analysis done for EdTech Readiness of the State, top 4-5 districts can be chosen for demonstration sites, based on the size of the State. Additionally, other factors like proximity of the district from the state administration office (SSA, SCERT etc) may also be considered for easy monitoring purposes. This would ensure effective administrative response and therefore understand the impact of EdTech.

2. School Selection

For in-school programs, integrated schools, which have better infrastructure and facilities may be better equipped to implement EdTech programs. This will also provide flexibility to states for designing programs for grades and subjects within these schools as per their priorities. For instance, if the priority is the FLN Mission, the states can leverage EdTech for early grades within these integrated schools. Additionally, other factors such as availability of computers, IT trained teachers, urban/rural, internet, etc., may also be considered.

B. Fit to Purpose EdTech Procurement

During procurement of EdTech, the states need to make decisions on the type of EdTech to procure, the process of procuring EdTech, and the relevant learning software.

1. Decide the Type of EdTech

Once the State has done the needs assessment and has identified the program intervention needed, the State would understand the type of EdTech to choose (1:1 or 1:many solutions)

2. Finalize the Process of Procurement

The ICT@Schools scheme has given options for procurement like GeM and BOOT models. Currently, with the aim to provide hardware to a maximum number of schools, cheapest hardware which meets the technical and financial bid criteria are selected. These come bundled with software and content, often of sub-optimal quality, greatly hampering the overall performance of the initiative. Hence, there exists a need to procure hardware, software and service in unison. To this end, States need to decide the process of procurement as discussed below.

A. Centralized vs Decentralized Procurement

	Centralized	Decentralized
Centralised Procurement	Capacity of states to procure is higher	Greater ownership
	Bargaining power is higher	Strongly contextualised solutions
Decentralised Procurement	Smoother at scale programs due to uniformity	Smaller tender values leads to higher rate of successful RFPs being passed by the system
	Process for passing approvals for larger tender values can be protracted	Lack of uniformity, interventions remain isolated and no scale benefits unlocked

B. Bundled vs Unbundled Procurement

	Bundled	Unbundled
What	Single Request for Proposal (RFP) that caters to hardware (HW), learning software (SW) and the service layer	Separate RFP focussed on software procurement and a separate one focussed on hardware and/or service layers
	• Single point of accountabilty to drive integrated programs that are easier to execute and manage • Shorter process	• Adequate focus on quality of software, harware and system integrators independently
	• Typically HW drives the bid, need to design processes to ensure learning SW is given due weight • At the back end, it may be a consortium play, that brings its own complexities	• Protracted process as multiple RFPs need to be published and closed • Programmatically more complex as multiple stakeholders need to be working together closely

3. Select the Relevant Learning Software

To ensure that EdTech programs help in achieving requisite goals, quality and relevance of software are important. Currently, there is limited information about the quality of Edtech solutions available for adoption. Thus, the States may use a product evaluation index, such as EdTech Tulna, (mentioned in the Current State of EdTech in India section) which can provide an unbiased, quality assessment of the ecosystem to drive decision-making on EdTech adoption and address this information asymmetry. Alternatively, States may need to run a Proof of Concept of select vendors before empanelling them.

C. Capacity Building of Individuals and Institutions towards Sustainability

1. Institution at the State Level

Creation of a Technical Support Unit (TSU) under the State education department to support the State with the planning, design and implementation of all EdTech initiatives. It is recommended to establish a TSU at the district level as well.

2. ICT Training for Teachers and Middle Management

Teachers must be provided with training in all domains of ICT literacy, ICT curriculum and ICT enabled pedagogy ensuring smooth integration of EdTech in traditional learning environments. Affinity with devices and their utilization in a targeted manner for both teachers and middle management staff can lead to increased impact.

3. At-Home Learning

Awareness and Empowerment of Parents: Parents need to be aware of the available EdTech solutions and capable of adopting EdTech at home.

D. Monitoring Framework for EdTech

Regularity in usage and mapping outputs are critical elements for any EdTech platform. Therefore, a continuous monitoring framework needs to be put in place.

- Real-time dashboards that can show utilization and student performance on a granular level.
- System enabled feedback loops which can help in improving teaching and learning
- SLAs with partners around metrics like usage, engagement, etc.

Based on the learnings from demonstration sites, States can start expanding the EdTech interventions to other districts/schools eventually ensuring that all schools get covered.

Key Parameters to Understand the EdTech Readiness of the State

For In-School Programs

1. Current Status of Hardware in Schools across the State

- Number (and state) of computer labs and number of desktops
- Number of smart classrooms/digital classrooms (not more than 50 pupils per digital classroom)
- Number of laptops available
- Availability of electricity in schools
- Status of internet connectivity
- Status of supporting infrastructure including furniture, UPS, stabilizers, headphones, routers, etc.

2. Current Status of Software and Content Used for Learning

- Edtech software currently being used in different programs, along with checking for effectiveness (if feasible)
- Current process in place for data collection and analysis of the data generated by the existing EdTech softwares- How is the data being used for decision making
- Availability of e-content in play-based, animated mode and in local languages

3. Current Status of Individual and Institutional Capacity

- Total number of teachers per school vs availability of teachers who have undergone ICT training and leverage tech while teaching
- Presence (and status) of the IT cell or equivalent in the State and their regular training
- Total number of school leaders and middle management staff including BEO, CEO, BRC, CRC, etc., who have undergone ICT training
- Total number of Field Management Staff (FMS) deployed by vendors to check if they are sufficient

For At-Home Programs

1. Current Status of Hardware Penetration at Homes with Parents

- Percentage of parents/households with smartphones
- Percentage of parents/households with feature phones
- Percentage of households with TV
- Status of internet connectivity at homes
- Access to required data packs by telecom operators or community hotspots
- Status of communication channels among parents and teachers
- Status of community support groups - virtual or in person - for parents
- Presence of family members besides parents who can support students, similar to Shiksha Mitras in Haryana

2. Current Status of Content and Software needed for Home Learning

3. Current Status of Parent's Capacity (Indicated by Parent's Educational Level) and Bandwidth (Indicated by Parent's Time Spent at Work)

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