

NATIONAL DIGITAL EDUCATION ARCHITECTURE

NDEAR



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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
API	Application Programming Interface
AR/VR	Augmented Reality / Virtual Reality
CBSE	Central Board of Secondary Education
BRC	Block Resource Center
CCC	Command and Control Center
CEO	Chief Executive Officer
CIET	Central Institute of Educational Technology
CRC	Cluster Resource Centre
CSC	Common Service Centres
CSR	Corporate Social Responsibility
CWSN	Children with Special Needs
DIKSHA	Digital Infrastructure for Knowledge Sharing
DoSEL	Department of School Education and Literacy
ECCE	Early Childhood Care and Education
EdTech	Education Technology
FLN	Foundational Literacy and Numeracy
GSTN	Goods and Services Tax Network
HPC	Holistic Progress Card
ICT	Information and Communication Technology
ID	Identity Document
IDER	India Report on Digital Education
IEC	Information, Education and Communication
IndEA	India Enterprise Architecture
ISO	International Organisation for Standardisation
IVR	Interactive Voice Response
KPI	Key Performance Indicator
MeitY	Ministry of Electronics and Information Technology
MIS	Management Information System
ML	Machine Learning
MoE	Ministry of Education (formerly known as Ministry of Human Resource Development (MHRD))
MoHFW	Ministry of Health and Family Welfare
MSDE	Ministry of Skill Development & Entrepreneurship
NAS	National Assessment Survey
NCERT	National Council for Education Research and Training
NDEAR	National Digital Education Architecture
NDHM	National Digital Health Mission

NDSP	National Data Sharing Policy
NEP 2020	National Education Policy 2020
NETF	National Educational Technology Forum
NGO	Non-Governmental Organisation
NIC	National Informatics Centre
NITI Aayog	National Institution for Transforming India
NODE	National Open Digital Ecosystems
NPCI	National Payments Corporation of India
NROER	National Repository of Open Educational Resources
ORF	Oral Reading Fluency
OTP	One-Time Password
PAN	Permanent Account Number
PARAKH	Performance Assessment, Review, and Analysis of Knowledge for Holistic Development
PDP Bill	(Indian) Personal Data Protection Bill, 2019
PII	Personally Identifiable Information
PM WANI	Pradhan Mantri Wireless Access Network Interface
PMU	Programme Management Unit
PSC	Project Steering Committee
PSSB	Professional Standard Setting Body
QuML	Question Markup Language
SAS	State Assessment Survey
SCERT	State Council of Educational Research and Training
SDG	Sustainable Development Goals
SMS	Short Message Service
SoR	System of Record
SQAAF	School Quality Assessment and Accreditation Framework
SSA	Sarva Shiksha Abhiyan
SWAYAM	Study Webs of Active-Learning for Young Aspiring Minds (https://swayam.gov.in/about)
TERM	Teacher Energised Reference Manual
TLM	Teaching Learning Materials
UDISE+	Unified District Information System for Education
UIDAI	Unique Identification Authority of India
UNICEF	United Nations Children's Fund
UT	Union Territory
UX	User Experience
VOIP	Voice over Internet Protocol
WCD	Ministry of Women and Child Development

GLOSSARY

Building Blocks	A package of self-contained functionalities defined to meet business needs through a set of services made available via APIs and optionally via reference solutions. Building blocks have to interoperate with other building blocks within the same system or across systems.
DigiLocker	A platform for issuance and verification of documents and certificates in a digital format, thereby eliminating the sole reliance on physical documents.
Digital Infrastructure	A set of open-source components / building blocks that can be used to configure solutions of various kinds for the beneficiaries and users.
Ecosystem	A range of actors and stakeholders in the education ecosystem such as Central and State/UT governments; School systems (government, private, formal, informal, alternative); Civil society organisations, community, private entities; Education experts, pedagogists, technologists; Learner, parent, teachers and school leadership.
Education Locker	A standards-based interoperability specification that can be implemented by multiple players to enable the creation of an Education Record ecosystem.
Energised Textbooks	Energised textbooks (ETB) provide access to efficient learning experience for students by linking relevant digital learning resources to the textbook. The resources are available for any-time, anywhere offline and online use across various consumption interfaces.
Federated	Distributed and decentralised systems to preserve autonomy and agency of States, departments organisations and institutions. These systems must be interoperable through common standards and specifications, while maintaining their independence.
India Stack	A set of APIs that allows governments, businesses, startups and developers to utilise unique digital Infrastructure to solve India's hard problems towards presence-less, paperless, and cashless service delivery.
Interoperable	For systems to be able to connect with each other on a need-basis through open specifications and APIs. This includes interoperability (based on appropriate rules, administrative and legal frameworks) across systems and domains such as health, child development, social justice, juvenile welfare, tribal welfare and others.
Microservices	Building blocks which can be used by a builder of a platform or solution to compose many solutions rapidly, and even rewire them, depending on the context, diversity and needs, rather than rewriting the full technology stack.
Multimodal coherence	A means to enable inclusive and equitable access to digital learning content via TV, radio and digital platforms like DIKSHA, SWAYAM.
Open-Source	A software for which the original software code is designed to be publicly accessible—anyone can see, modify, and distribute the code as they see fit.
Phygital	Physical plus digital

Public Good	A commodity or service that is made available to all members of society. It enables others to take, use, reuse, build and contribute back.
Registries	A service with open APIs where master data about schools, teachers, students, administrative officials, subjects, textbooks, etc are maintained.
Sunbird	An open-source, configurable, extendable, modular learning management infrastructure architected for scale. It is designed to support multiple languages and multiple teaching and learning solutions.
Synchronous Learning	All types of learning in which learners and teachers are in the same place, at the same time, in order for learning to take place. In-person classes, online classes, audio/video conferencing, phone call etc are examples of these. Asynchronous learning are learning interactions where users interact with each other without being physically or virtually available at the same time/ place e.g. chat, discussion boards, etc
Unbundled	Building blocks and components that exist on their own and can be brought together to allow the creation of multiple solutions.

Messages

धर्मेन्द्र प्रधान
ଧର୍ମେନ୍ଦ୍ର ପ୍ରଧାନ
Dharmendra Pradhan



मंत्री
शिक्षा; कौशल विकास
और उद्यमशीलता
भारत सरकार



Minister
Education; Skill Development
& Entrepreneurship
Government of India

MESSAGE

The National Digital Education Architecture (NDEAR) 2021 outlines the framework to energize and catalyse the digital education ecosystem to create and deliver diverse, relevant, contextual, innovative solutions that benefit students, parents, teachers and educational communities.

In the year 2020-21, majority of the children in our country had little experience of school as an institution owing to the COVID-19 pandemic. Facing this challenge and pushing forward for a brighter future needs urgent action, new approaches, technological tools and a variety of actors and stakeholders to help us achieve the goal of universal access to quality education and promote lifelong learning opportunities by 2030.

In the midst of an unprecedented global crisis, this challenging time can be seen as an opportunity to find innovative ways to effectively leverage technologies for efficient solutions. This can be achieved with a firm resolve. Various technological tools can be used to access categories of students, more so during these times.

The blueprint is aligned with the vision of our Hon'ble Prime Minister Shri Narendra Modi to serve the needs of learners, teachers and administrators by the digital education ecosystem in India. The successful implementation of this blueprint will help achieve learning outcomes by offering solutions to learners and teachers.

I appreciate the contribution of Shri J. Satyanarayana and other members of the Committee for their commendable work in preparing the blueprint. I request all stakeholders to implement this seriously and pave the way for transforming India's education platforms into a 'unifying' digital architectural ecosystem.

(Dharmendra Pradhan)



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Messages

अन्नपूर्णा देवी
ANNPURNA DEVI



राज्य मंत्री
शिक्षा मंत्रालय
भारत सरकार
MINISTER OF STATE
FOR EDUCATION
GOVERNMENT OF INDIA

Message

The Indian Education ecosystem is a large, complex and diverse network. The diversity is apparent in the wide array of schools, medium of instruction, solutions across government/private sector including the need of the learners too. In an ever-changing world, where learning needs of learners and teachers have to keep pace with the times, the role for a diverse ecosystem to be able to deliver relevant and quality services in an agile manner is very essential.

The only way to cater to these aspirations is to enable widest technology driven ecosystem to thrive and deliver, so that the policy goals of NEP 2020 are implemented including India's commitment to SDG 4 of "inclusive and equitable quality education and lifelong learning for all".

There is a need for a technology framework, architecture and an ecosystem approach to allow different stakeholders to participate in and create solutions in an exponential manner, in order to nurture out young to achieve their potential.

I am sure that the principles of National Digital Education Architecture (NDEAR) would provide necessary framework to all for strategizing the digital education ecosystems.

For providing the much needed momentum of the hour, the Department has framed NDEAR as a technological framework that aims to enable existing systems to upgrade and become interoperable, while making available, the building blocks for the creation of new tools and solutions for a unifying architecture to deliver the needs of the educational requirements of the country.

I appreciate the efforts of the of the committee members who have relentlessly worked to frame this report capturing all aspects of the present Indian education ecosystem summed into a digital framework for everyone to adopt considering all steps for effective implementation of the digital blueprint across the education spectrum.

Annpurna Devi
(Annpurna Devi)

Messages

अनीता करवल, भा.प्र.से
सचिव

Anita Karwal, IAS
Secretary



Message

स्कूल शिक्षा और साक्षरता विभाग
शिक्षा मंत्रालय
भारत सरकार
Department of School Education & Literacy
Ministry of Education
Government of India

The progress of India in the coming decades will be fuelled by the participation of children and youth who should be able to tap into the opportunities offered by a growing economy that is becoming increasingly digital in nature. The technology needs of the school education ecosystem in India are vast and varied, not all of which can be solved by the government acting in a standalone fashion. The National Education Policy, 2020 in para 24.4 (b) states very clearly 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."

National Digital Education Architecture (NDEAR) has been conceived as a unifying National Digital infrastructure to energise and catalyse the education ecosystem. The core idea of NDEAR is to facilitate achieving the goals laid down by National Education Policy 2020, through a digital infrastructure for innovations by, through and in the education ecosystem, ensuring autonomy and participation of all the relevant stakeholders. It will pave the way to achieve learning outcomes by offering solutions to learners and teachers. Besides, it will also recognise the digital rights of our children and evolve best practices to ensure safety and security from untoward exposure. Ultimately, it will enable more comprehensive access and faster cycles of innovation in the education sector leveraging technology tools.

This blueprint has been debated, discussed, decoded and detailed by experts led by a National level NDEAR Steering Committee, consisting of and ably guided by Shri J. Satyanarayana and Shri Ajay Sawhney, Secretary, MeitY, Government of India. This blueprint has seen the light of the day due to the persistent and systematic efforts of Shri Manoj Ahuja, Chairperson, CBSE; Dr. Neeta Verma, DG NIC and her team; Dr. Pramod Varma, Shri Shankar Maruwada and Shri Jagadish Babu from EkStep Foundation; CSF Team; Shri Rajnish Kumar, Director, DoSEL, and all the other members of the Steering committee and sub-committees. I deeply acknowledge the huge contribution of the members of the Steering Committee and all the other contributors for their time and commitment in helping us in creating the NDEAR blueprint for India. I also reiterate the commitment of Government of India to take all necessary steps for effective implementation of the digital architecture for the education of our country's present and future generations.


(Anita Karwal)

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Messages

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Chief Advisor, C4IR India,

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Message

Education is the most powerful weapon which you can use to change the world.

- APJ Abdul Kalam

Education is the foundation of the development of a nation. The National Education Policy 2020 emphasizes the critical need to provide equitable opportunities of learning on a universal basis. The size and complexity of the issues surrounding education systems in India call for radical and innovative approaches. We need to *do more with less* – at a great pace.

The current approaches to education include re-orienting the curriculum towards imparting cognitive skills, values and culture, a focus on foundational learning and numeracy, creation of immersive content, and enabling the students to *learn to learn*, and teachers to *learn to teach differently*. We need to create an environment that enables the education ecosystem to grow rapidly in these desirable directions. Education Technologies, fortified by emerging technologies like artificial intelligence can accelerate our progress. Digital education is a concept the time for which had arrived a few years ago, and its urgency has been brought to the fore by the pandemic.

NDEAR is a set of principles, standards, specifications, building blocks and guidelines that enable multiple entities to create parts of the digital education ecosystem - independently but interoperably. Depending upon the nature of the entity, the outcomes to be achieved, and the scale, the components of NDEAR can be combined suitably to produce the desired results. This unique approach has been evolved to meet the widely varying requirements of the stakeholders in the diverse landscape of India. NDEAR is not prescriptive, but indicative. Its foundational features include a federated architecture, a set of core building blocks and a strong focus on outcomes.

NDEAR has drawn up a large canvas that spans public and private sectors, centre and the states, voluntary organizations, varying socio-economic levels and the entire range of stakeholders committed to improving the state of learning and education in the country. Critical to its success are factors such as cooperative federalism, wide adoption of the principles and standards, embracing emerging technologies, innovation, and above all, a multi-stakeholder approach in its implementation. All said, NDEAR can make a significant impact if it can help generate immersive content created in a collaborative way and made accessible at population scale through low-cost devices designed just to meet the learning needs.

I hope that true to its name, NDEAR would soon endear itself to the stakeholder community, get widely adopted and make a difference to the students, including those in the remote areas and the under-served communities.

A handwritten signature in black ink, appearing to read 'J Satyanarayana'.

J Satyanarayana

Co-Chair, NDEAR Task Force

June 2021

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NDEAR

Part A Overview



Objective of this document



Executive Summary



Illustrative Case Studies - NDEAR



Questions

This document is meant to be an evolving blueprint for National Digital Education Architecture. It lays down a set of principles and approaches for the development of digital platforms and diverse solutions to serve the needs of learners, teachers and administrators of education, by the education ecosystem and digital ecosystem in India. The objective of this document is to seek comments from stakeholders and the ecosystem to improve the blueprint for National Digital Education Architecture.

This document may be read in the following manner:

- a. Part A contains the overview and the Executive Summary. The case studies will provide a perspective on what NDEAR might mean for teachers, learners and the education ecosystem in general. The section on “Questions” will address some open questions with respect to NDEAR for administrators, states and the ecosystem.
- b. Part B contains an elaboration of the detailed scope and principles that will drive NDEAR; its technical architecture; institutional framework and priority areas.

In the academic year 2020-21, the majority of children in India hardly met their teachers or experienced school. Teachers across the country did not get to see bright eyes, smiling faces, experience loud chatter, laughter or the clatter of young feet outside classrooms.

In July 2020 the Government of India announced the National Education Policy (NEP) – a mandate and north star for education from K-12 and beyond.

In the year 2020, it has become evident to the world that the Sustainable Development Goals (SDG's) which were to be achieved by countries across the world by 2030, are in danger of not being achieved.

Facing the challenge and pushing forward to a brighter future needs urgent action, new approaches, technological tools and a variety of actors and stakeholders to do everything they can to solve problems at the ground level for the sake of teachers and learners. This will give us a fighting chance to achieve the goal of universal access to quality education in 20 years – a goal of the NEP and to fulfill India's commitment to SDG 4 of "inclusive and equitable quality education and promote lifelong learning opportunities for all" by 2030.

Doing more of the same has worked in the past, but it may not achieve the desired results for the future. Tools, frameworks and solutions are needed to equip every actor in the education ecosystem to solve for what they can in areas within their reach. These actors are parents, teachers, the students themselves, administrators, local communities as well as government, civil society and private organisations.

India has been successful in enabling access and inclusion through leveraging technology, particularly with developing digital infrastructure for access and inclusion. In this context, the idea of digital infrastructure is not limited to access to bandwidth, data and devices. While these are critical pieces of digital infrastructure, we need to widen the scope to include open source software, standards, specifications and policies to support diverse solutions and actors, enabling wide access while empowering and protecting individuals. India has experienced great success in identity, financial inclusion and payments by taking this approach.

The need for a similar digital infrastructure approach to widen access and deepen impact is urgently being felt in the area of education – not in the least because of NEP, 2020 and COVID-19, but also, to provide a stable, yet evolving framework for digital infrastructure for education for the future generations.

Much like building schools and playgrounds, teachers and students, curriculum, pedagogy and teacher training comprising the tangible and intangible aspects of education, the development of digital infrastructure and architecture for education needs to be viewed in the same way. It is a combination of tangible and intangible, physical and digital, synchronous and asynchronous, improving efficiencies and enabling solutions and tools – retaining at the core of it all, the idea of enabling learning and progress for the young learners of India.

There is a need for a technology framework, an architecture and an ecosystem approach to allow different stakeholders to participate in and create solutions in an exponential manner, to nurture our young to achieve their potential.

The needs of the education ecosystem in India are varied, not all of which can be solved by technology. However, technology can play a role in supporting and bringing efficiencies to processes, create more time and spaces for learning and also enable wider access and faster cycles of innovation. India is on solid ground to leapfrog at scale to a new equilibrium in the education sector by leveraging technology tools. Building monolith technology solutions for a diverse country with varied needs is a non-starter. In addition to being expensive, it is imprudent to put all eggs in a single basket. At the same time, across the country, the education ecosystem consisting of the government, civil society and private organisations

are investing in programmes and solutions for learning. Several of these innovations are successful but have limited impact due to the inability to scale or the inability to reuse components. As a result, there is immense repeat spending on developing similar solutions. As a government, If we acknowledge and understand the diverse needs of the education ecosystem, it becomes abundantly clear that the problem to solve is not to build solutions but to enable, curate, orchestrate and support diversity in an evolvable manner by the ecosystem.

Every learner should have access to learning experiences that are holistic, joyful to keep them engaged, happy, confident and thinking critically. There are a set of common needs and challenges:

- *Students, parents and teachers* need diverse content and learning materials for different learners across the country to be available in multiple languages; varied learning and teaching methodologies and upskilling of teachers; varied modes of delivery - in school, at home and in community, as evidenced by the disruptions of 2020; the need for multimodal access across device-types and distribution channels namely, TV, radio, mobile, computer; synchronous and asynchronous.
- *Administrators of education systems*, Centre and States need reliable data on programmes and policies being implemented at different levels – school, district, State and Centre. A single source of truth through interoperable systems, without compromising the federal nature and structure of education in the constitution, nor denying the agency of states and schools in the country.

This is where NDEAR comes in – a **National Digital Education Architecture** with a vision to create a “Unifying national digital infrastructure to energise and catalyse the education ecosystem”. Essentially, this is a technological framework that aims to enable existing systems to upgrade and become interoperable, while making available, the building blocks for the creation of new tools and solutions. NDEAR aims to energise and catalyse the digital education ecosystem to create and deliver diverse, relevant, contextual, innovative solutions that benefit students, teachers, parents, communities, administrators resulting in timely implementation of policy goals.

The NDEAR Committee was set up with a mandate to develop the blueprint for digital education architecture – the NDEAR committee is co-chaired by Shri J Satyanarayana, former Chairman, UIDAI and Smt. Anita Karwal, Secy. Department of School Education and Literacy (DoSEL). The Committee created four sub-groups to delve deep into the following aspects:

- a) Scope of NDEAR
- b) Technology and Architecture Principles
- c) Institutionalisation of NDEAR
- d) Focus Areas – Foundational Literacy and Numeracy and DIKSHA – National School Education Platform. Each sub-group had representatives of the Ministry of Education (MoE), NCERT, CBSE, Ministry of Electronics and Information Technology (Meity) and others, along with representatives of civil society working on education and technology.

NDEAR sets out

- Principles - e.g. technology, building blocks and ecosystem
- Standards and Specifications - e.g. technology and data
- Guidelines - e.g. data processing; ecosystem engagement
- Policies - e.g. data protection; openness; inclusion; accessibility

For an ecosystem

- Actors to build, develop, innovate
- Applications/Innovations in the form of solutions, platforms, tools, assets to be developed and used



NDEAR is federated, unbundled, interoperable, inclusive, accessible, evolving – *essentially a ‘distributed, adaptive and open socio-technical system with the ally properties of self-organisation, scalability and sustainability’.*

The Core idea of NDEAR

- A. **“Building blocks”:** An initial set of 36 building blocks across 12 categories have been identified to kickstart the digital infrastructure for education. The idea is not for NDEAR to build these blocks or to use these blocks for solutions exclusively. Some building blocks may exist, some may need to be developed, others repurposed in/for the education ecosystem. As long as they are compliant and compatible with NDEAR, they may be used by governments, civil society and private organisations to develop relevant platforms, solutions and programmes for students, teachers, parents, administrators and the community.
- B. **“Ecosystem – Not a system”:** The diversity of the education ecosystem in a federal structure like India does not need to be stressed. Diversity comes in the form of Centre – State responsibilities and accountability for educational outcomes and service delivery; Government and Private school systems; there are multiple Boards; linguistic diversity, and most of all, diversity of learner needs across a spectrum of gifted to those with special needs and the differently-abled or atypical. To control, regulate and monitor cannot be the approach to achieve the learning outcomes. The key objective of NDEAR would be to enable and catalyse the rich and diverse education ecosystem of governments, autonomous bodies, civil society and private sector players to build and contribute to:
 1. Technology building blocks
 2. Solutions for learners and teachers and
 3. Help achieve learning outcomes

NDEAR will enable solutions for a coherent, multimodal, multi-channel learning continuum

2 Core Interactions

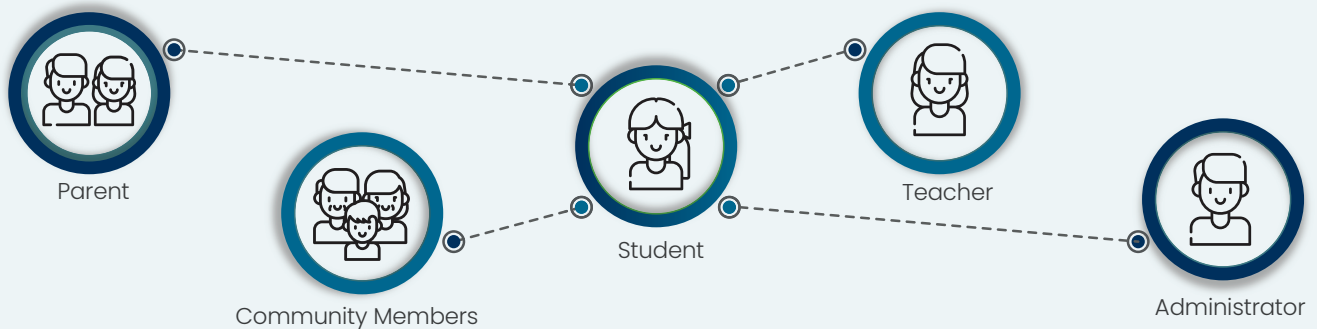
Learning Interactions,
Administration Interactions

3 Scenarios

Learn, Help Learn, Manage Learn

5 Key Personas

Student (any learner), Parent (any caregiver), Teacher (anyone providing formal/Informal teaching) Administrator (anyone who can help manage) Community Member (anyone from society, including market players)



ENABLING COHERENT MULTI-CHANNEL MULTIMODAL LEARNING CONTINUUM

Sync/Async, Offline/Online, Physical/Digital, Self-service/Assisted

ON A FEDERATED PUBLIC DIGITAL INFRASTRUCTURE

Built using 36 Building Blocks, within 12 categories

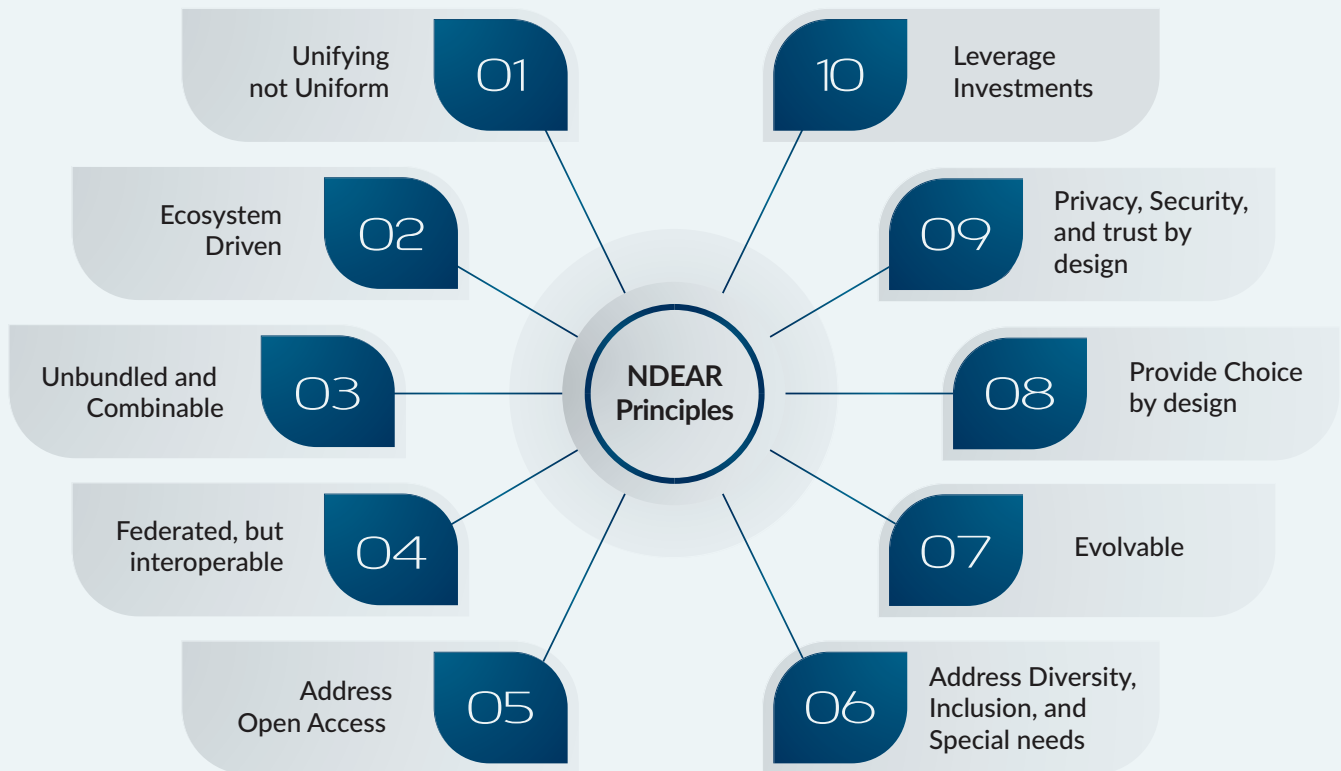
ACROSS 3 ADMINISTRATIVE LEVELS

Centre, State/Board, School

LEVERAGING 3 ECOSYSTEMS

PROGRAM, ASSET, SOLUTIONS Ecosystems
Across GOVERNMENT, SOCIETY and MARKET Actors
Via Transparent Rules, Enabling Tools, Participatory Governance

NDEAR's Design and Technology Principles



A Unifying and Evolving Design

NDEAR's Institutional Structure

The Institutional structure being considered for NDEAR must meet the following criteria; the intent is to have an institutional and governance structure that:

- Has a minimal footprint
- Is evolvable and agile
- Is federated and inclusive (Centre - State - Public - Private - NGO)
- Will enable and catalyse through a multi-stakeholder ecosystem

It is not intended that NDEAR be set up as a new institution, but rather a unit of an existing entity or a proposed entity such as the National Education Technology Forum envisaged in the NEP. In the interim, a Project Management Unit incubated under the Secretary, DoSEL, Ministry of Education will initiate the work of NDEAR.

NDEAR - Priority Areas and Implementation Plan

The MoE is undertaking several new missions and programmes - key among them are SSA and National Foundational Literacy and Numeracy mission. The MoE and several states across the country have invested and continue to invest in technology for education - some details of these may be found in the India Report on Digital Education 2020. At the central level, DIKSHA, SWAYAM and UDISE+ are used for different purposes. In light of the expansion of missions and interrupted schooling, the MoE has identified the following priority areas for NDEAR - namely Registries and Digital Infrastructure (Building Blocks) for, among others, Foundational Literacy and Numeracy, Samagra Shiksha, PM e-VIDYA .

A. Transferring Schools With Ease

David is in the 7th grade in Madurai in Tamil Nadu. David's father and mother have already moved to Chennai. David will join them after the exams in March. His father needs to find a school in Chennai, get all necessary paperwork from the old school, give it in the new school, find financial support for David's high school education, and given David's interest in cars, explore additional skilling opportunities. All these, while he settles into his new job in Chennai, not having leave, but, forced to visit Madurai for obtaining various certificates and completing paperwork.

These pain points are a thing of the past. With NDEAR building blocks, there are solutions that enable :

- 1-click login using David's student ID to school admission system.
- 1-click link to David's "learning passbook" with no additional forms to fill.
- David opting in for receiving a financial grant.
- David's parents to enable digital access to his learning passbook by express consent to a CSR fund offering scholarship.
- Request to the old school, with just 1-click, for all transcripts including the Transfer Certificate, without filling any forms.
- Receipt of notification of all transfer docs available in Digilocker.
- 1-click consent to the new school to access transfer docs.

B. "My Freedom to Help my Daughter Learn"

Rui is a smart, energetic and lively 5-year-old and studies in a government primary school. Her school-educated mother is worried that Rui is not ready for grade 1 – she cannot read well or write in Marathi; they speak Urdu at home. Rui's mother expresses her concern to the class teacher, who tells her that it is important to create a learning environment for Rui at home and she could help her. She is given a sheet with QR codes and advised to use these to download and print materials for Rui.

She asks her husband to go to the local PM WANI enabled wifi touch point and internet centre and use the codes to print worksheets, download the videos and activities on his phone. A small fee of Rs 10 is paid for the printouts. This visit is now a weekly routine for her family.

Rui and her mother now listen to stories, learn new words and do math activities using utensils, sticks, stones available in and around the house. One of the QR codes has a link to a game to identify letters, words and number operations. Rui can be seen scoring higher points on this game every week. Rui loves to play this game on her own and wants to get more points in the game.

NDEAR building blocks and ecosystem approach made the following possible:

1. The State to source curated bi-lingual activities, stories and materials for school readiness, from NGOs, experts.
2. The game: a byte-sized assessment was created at a hackathon enabled on an NDEAR-compliant innovation sandbox for digital pedagogy – to be available to use at scale. Aggregate data from mass casual usage is available to sense the pulse of learning for school readiness.

3. The DIKSHA platform and learning services related building blocks made it possible for SCERT to curate school readiness packages for different age groups and needs.
4. The QR codes/ numeric codes and activities are accessed by parents, at their own time, locally, with their resources to create learning environments at home.

C. Following Your Interest and Skills

Birsa is 14-years-old. He is intelligent, quick with his hands and a fast learner when it involves building with wood or repairing broken equipment. He struggles in school and his marks do not reflect the intelligence and capabilities he shows in working with his hands. After school, every day he works on the family farm and at his relatives' carpentry and electrical repair shop. While he struggles with describing the pulley system in a physics class test, he knows exactly what it is and how it works in real terms. He finds this frustrating. He knows more than he can express and he can do more than his school or examiners realise.

Birsa's father heard of a programme by the Skills Ministry (MSDE) to encourage young people to take vocational courses, get certificates and use this to go to Industrial Training Institutes (ITIs) for further studies and that a stipend is also provided into their bank accounts for successful applicants.

- The Common Service Centres (CSCs) in the village had a poster on the different courses that young people could take online and get certificates.
- Birsa's CBSE school also encourages vocational training and internships for highschool students, in line with the NEP.
- Birsa is able to choose the courses he wanted to do in his free time at the CSC and receive digital certificates to keep in his digital passbook online.

NDEAR's building blocks are used to develop solutions that make initiatives across ministries and departments interoperable:

- The course was provided by the National Skills Development Corporation and was also available for use on the DIKSHA - National School Education Platform.
- The digital certificates were possible to be showcased for school work with CBSE as well as for further applications and to receive scholarships.
- The solutions were available for use locally through existing distribution networks such as Common Service Centres (CSCs).

D. Digital Helping Hand for Every Learner and Teacher – Energised Schooling

Surya is an 8th grade, Odiya medium student and his class teacher, Das Sir teaches high-school Physics.

For the past two years, Surya had been struggling to catch up in Science. Concepts had become difficult to understand and catching up with class seemed like a losing race where he had fallen behind. Surya liked science and he wished to quickly understand class lessons and catch up with his class.

Das Sir knew that a good number of students like Surya have fallen behind. He wished to help them understand concepts and catch up to the rest of the class. He wished to have a clearer understanding of each child's learning profile so he can help better by providing customised feedback. He also wished to improve his teaching skills and learn more about interactive teaching methods that made learning easy for Surya.

1. DIKSHA leverages the NDEAR building blocks. It provided Das Sir with physical and digital assessment tools connected to learning outcomes in the curriculum.
2. These tools were easily available to Das Sir on his phone even when he was offline, as they were linked to QR codes embedded in each chapter of energised textbooks provided by the Board.
3. Energised textbooks compliant with NDEAR learning services building blocks were easy to use by leveraging the DIKSHA mobile app and web portal.
4. Combining the assessment results with an NDEAR compliant decentralised, federated and privacy-protected student registry for his class, Das Sir was able to quickly develop a learning profile of his students and understand each student's learning better to craft a learning journey for his students.
5. The visualisation of class learning profile was made possible due to data and analytics building blocks of NDEAR.
6. Das Sir could now refer Surya to interactive videos, projects linked to energised textbooks for topics Surya was weak in, all based on his assessment results.
7. Surya could replay lecture videos linked to his topic of interest, as it helped him to clarify concepts better after going over the interactive simulations and explanations.
8. Surya tested his understanding by taking up assessments linked to QR code.
9. Das Sir was able to see the progress digitally, on his phone, as reflected in Surya's learning profile.
10. Meanwhile, Das Sir continued to leverage Teacher Energised Reference Manual (TERM) enabled by NDEAR. This provided him with various teaching methods, reading material, interesting questions and answers, which helped him to better engage the class and help students learn.
11. Further, Das Sir signed up for online courses on DIKSHA linked to high school Physics in Odiya, to learn advanced teaching methods. He could complete his course at his own pace and from the convenience of his home and school, without travelling long distances and losing valuable teaching time.
12. These NDEAR compliant courses and tools were proving to be a great help to Das Sir to skill himself up.
13. Das Sir's course completion certificates were now visible on his profile and were noticed and appreciated by his seniors as well, and also printed and proudly displayed by the school HM in the school notice board, for all the children and the community to see.

E. NDEAR Brings Efficiency and Effectiveness to School Administration

Rekha is a district school administrator in Udalguri district of Assam and Hemant is a teacher at the Primary school in Bandai village in the same district.

Rekha and Hemant had one common frustration – data, but from different points of view.

Hemant often had to update the administration on the status of many different projects and schemes implemented in the school. These tasks had a lot of reporting involved and often resulted in duplication of efforts across projects. More importantly, these tasks kept him away from teaching and his own professional development. Also, he was not sure of the value of data collection, since

almost always, no reports, insights or feedback came back to him from the data he was generating and sending to seniors.

Rekha had the reverse problem: Making sense of a lot of data. Data arrived in various silos constantly through excel sheets and MIS software and would take a lot of her time to clean up before relevant conclusions could be drawn. Often data had accuracy issues as well, resulting in further delays before she could make sense and act on her projects. She even spent non-office hours catching up and completing work. Rekha desired to be more efficient and effective at work.

Rekha and Hemant found NDEAR-energised administration tools to be very useful to solve both of their issues. Leveraging these tools, both of them could now spend a lot more time on tasks that truly mattered.

Hemant leveraged DIKSHA Projects to regularly update the status of various projects assigned to him, using his smartphone. DIKSHA Projects leverages NDEAR building blocks and is designed to bring efficiency in creating and managing projects. DIKSHA Projects enables the one-touch update functionality, which helps Hemant save time. DIKSHA Projects leverages school and student registry to help Hemant accurately find and update information related to his school and students. School and Student Registry leverages NDEAR's decentralised federated and privacy policy compliant identity building blocks. DIKSHA Projects connects to Registry to help Hemant update information related to projects.

Students' assessment data is now easily uploaded by simply taking a picture of students' assessment marks and AI tools would digitise them instantly. Data and analytical tools of NDEAR enabled Hemant to extract full insights from data instantly, which he used to identify students falling behind on learning levels.

Rekha now had the benefit of accurate, and most updated data, thanks to NDEAR's data building blocks. Data updated by Hemant on DIKSHA Projects was available to her team immediately. She was able to draw insights from data patterns instantly and owing to the accuracy of data, she did not have to spend any more time cleaning the data. DIKSHA Projects helped her with an accurate status of implementation and it was easy for her to act, where projects were falling behind. Rekha could now spend more time on tasks that mattered to her. Rekha could see district learning outcomes with one touch, thanks to NDEAR data and analytics building blocks, and provide better direction to her block and cluster level teams.

Energised Administration leverages all eight building blocks of NDEAR.

- a. *How does NDEAR differ from any technology project of the Government? Which ministry would NDEAR be a part of?*

NDEAR is not a project where the Government will be building technology solutions for the use of the education ecosystem. Through NDEAR, the Government will play the role of an enabler, providing a framework where technology can be built by anyone. Further, solutions that use NDEAR frameworks, standards and specifications, would be considered NDEAR compliant. Any technology solution which is NDEAR compatible will be able to connect with other solutions that are NDEAR compliant. State Governments would be free to embark on building solutions to suit their needs. NDEAR, by identifying needs and curating the building blocks needed for the education ecosystem, would be able to help with enabling the States with a leg up by providing technology components that can be configured for different solutions. This is much like selecting good quality bricks, which could be used to make any building of choice by the builder.

NDEAR is under the aegis of the Ministry of Education in collaboration with MeitY.

- b. *What would it mean to not have NDEAR?*

NDEAR is meant to enable a common set of principles and approaches to be followed in building, using and re-using technology for education. Without NDEAR :

- Systems would continue to function in silos without the ability to connect with each other and leverage their combinatorial values.
- Great innovations and solutions by States and the wider education community would not be possible to be leveraged by others.
- The lead time for getting technology projects and solutions by States and UTs would be longer.
- Solutions and ideas that have worked in a particular State, would not be reusable and reconfigurable by another and they would have to start from scratch.
- There would not be wide access to communities of practice and best practices leveraging technology in the Indian context.
- Data systems would not be able to talk to each other using a common framework, thereby curtailing policy-making, particularly to drive learning outcomes.
- There would not be common frameworks on data and policies around data. This would make technology systems and individuals vulnerable and may result in inconsistent handling of data, protection of individual data- particularly children's data.

c. *Would NDEAR be about centralisation and thereby undermining States' autonomy with respect to education and education data?*

NDEAR is not a control-oriented, centralised framework. It is inherently federated and designed to enable autonomy and choice, in keeping with the federal nature of education under the Indian Constitution. For example, in the context of Registries, NDEAR would provide the building blocks for the creation of Registries. This would mean that the States could use these building blocks to create their own Registries. Sharing information from the Registries to the Centre or to other departments would be dependent on administrative policies and practices that are followed, but the standards and principles will make it possible for different federated databases to share data. The existence of Registries as a building block does not mean a common centralised structure bypassing constitutional, legal and administrative rules and regulations.

d. *How will NDEAR ensure the protection of children and children's data?*

In consonance with the statutory framework and extant guidelines, NDEAR will come up with policies, standards and practices for the handling of data, particularly children's data to ensure compliance with existing and proposed data protection laws. In addition, NDEAR will recognise the digital rights of children and evolve best practices to ensure safety, security and protection from untoward exposure, harm and tracking.

e. *What would be the role of NDEAR in the context of evolving and emerging technologies?*

NDEAR is meant to be an evolving framework to keep pace with changing and emerging technologies, while staying true to its core principles. The NEP 2020 lays a significant emphasis on the use of emerging technologies like AI/ML,AR/VR/MR and DLT, for making a quantum change in the quality of education, governance, immersive content etc. These areas will be part of NDEAR and the NDEAR ecosystem approach will enable the wider ecosystem to participate and contribute in these areas.

NDEAR

Part B In-Depth Report

-
- Scope of NDEAR
 - NDEAR - Technology Architecture and Standards
 - NDEAR - Institutionalisation
 - NDEAR and Foundational Literacy and Numeracy
 - DIKSHA - National School Education Platform
 - NDEAR - Implementation and Priorities

1.1 Overview

The National Education Policy 2020 (NEP) lays down a high-level roadmap and goals for the country, for the next 20 years: “To achieve universal access to quality education”. This requires the development of digital infrastructure and the use of technology for access to and aiding learning. India is committed to attain Sustainable Development Goals by 2030 – the United Nations Sustainable Development Goal (SDG) 4 for Education requires countries to ensure “**Inclusive and equitable quality education and promote lifelong learning opportunities for all**”.

The key principles of NEP 2020 are as follows:

- **Respect for Diversity & Local Context:** In all curriculum, pedagogy, and policy
- **Equity & Inclusion:** As the cornerstone of all educational decisions.
- **Community Participation:** Encouragement and facilitation for philanthropic, private and community participation.
- **Focus:** On regular formative assessment for learning.
- **Use of Technology:** In teaching and learning, removing language barriers, for Divyang students, and in educational planning and management.
- **Emphasise Conceptual Understanding:** Rather than rote learning and learning-for-exams.
- **Unique Capabilities:** Recognising, identifying them in each student.
- **Critical Thinking and Creativity:** To encourage logical decision-making and innovation.
- **Teachers and Faculty at the Heart of the Learning Process:** Their recruitment, continuous professional development and service conditions.
- **A Light but Tight Regulatory Framework**

A committee has been constituted under the Chairpersonship of Smt. Anita Karwal and Shri J Satyanarayana (NDEAR Committee) with the objective of creating a framework and implementation plan for National Digital Education Architecture (NDEAR) for School Education. The Committee began its deliberations on August 21, 2020 to recommend the framework and a blueprint for NDEAR. The Committee consisted of members representing the Ministry of Education, MeitY, CBSE, NCERT, relevant departments and organisations working in the field of education and technology.

NDEAR is envisioned to be a digital infrastructure for School Education. The NEP 2020 has highlighted key critical reforms like setting up of the National Mission on Foundational Literacy and Numeracy, Universalisation of Early Childhood Care and Education, setting up of the National Education Technology Forum for school and higher education, setting up a dedicated institute for assessments (PARAKH), etc. The NEP 2020 emphasises the importance of the role that technology can play in solving critical challenges that our education system is facing today and achieving the goals set out therein.

The MoE as well as State governments across the country have been engaged in and support a range of digital initiatives and platforms, most significant of them being DIKSHA, SWAYAM and UDISE +. MoE’s *India Report on Digital Education (IDER)* – June 2020 documents several national and State-level initiatives taken to leverage technology, particularly in the context of disrupted schooling as well as preparing for a future state of leveraging diverse technology for learning. The MoE as well the States/UTs have a range of schemes and programmes being implemented across the country (For an indicative list of schemes, see Annexure 1).

Significant developments and innovations have happened in the education ecosystem with non-profit organisations and the private sector finding varied solutions to serve the needs of learners and teachers across the country. The education technology industry in India has been growing, with over 5000 education technology solutions available in India currently.

The disruptions in the schooling rhythm have resulted in several initiatives across the country. The PM eVidya programme was launched in May 2020 as part of Atma Nirbhar Bharat, with the objective to unify efforts across physical/digital education & enable equitable multi-modal access.

Within the context of a digital-first mindset of the government and a thriving education ecosystem including government, private, non-profit and technology sector, the NDEAR Committee has been set up. The Ministry of Electronics and Information Technology (MeitY) released a white paper in May 2020 on *National Open Digital Ecosystems (NODE)* - a new paradigm for GovTech.¹ The intent is to “enable open and secure digital delivery platforms, anchored by transparent governance mechanisms, which enable a community of partners to unlock innovative solutions, to transform societal outcomes.”

The core idea of NDEAR is to facilitate achieving the goals laid out by NEP 2020, through a digital infrastructure for innovations by, through and in the education ecosystem. This is the context in which the NDEAR Committee was constituted.

1.2 Context

1.2.1 Indian Education Ecosystem

The Indian education ecosystem is a large, complex and diverse network. Given the constitutional structure in which education is placed, it is also federal and autonomous. The diversity is apparent in the wide array of schools, solutions (non-digital and digital) across government, private sector and civil society, languages, mediums, Boards of education and learner needs. All of this diversity is reflected in the varying levels of skills and capabilities of actors, stakeholders and organisations, as well as in quality and outcomes. India has one of the largest school systems in the world: 25 crore children enrolled in about 15 lakh schools across the country.¹

NEP 2020 and SDG 4 set out areas of priorities and impact for India. In an ever-changing world where learning needs of learners and teachers have to keep pace with the times, the role for a diverse ecosystem to be able to deliver relevant and quality services in an agile manner and with constant innovation is critical. The educational aspiration of the Indian parent for their children is growing from generation to generation, as the link between education and the path for a better future and life for their families is clearly established in their minds. The only way to cater to these aspirations is to enable the widest ecosystem possible to thrive and deliver, so that the policy goals of NEP 2020 are implemented.

Characteristics of India's education Ecosystem

- Large, Diverse, Complex Network
- Federal and Autonomous
- Actors across Government, Markets, Non-Government
- Varied levels of Access, Capabilities, Quality, Outcome

For the sake of clarification, the term “**education ecosystem**” refers to and means organisations, institutions, departments, autonomous bodies, entities and individuals in the government, private and non-profit sector, and shall also mean to include learners, teachers, educators and the community at large.

1.2.2 India Leapfrogs in Technology

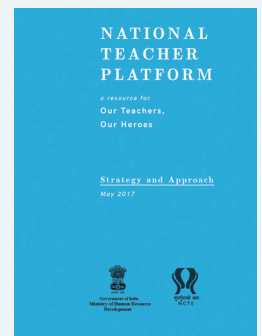
Technology has helped India leapfrog in multiple sectors. Ecosystems have been catalysed to deliver relevant services to end-users and beneficiaries through National Level Digital Infrastructure and Policies in domains such as digital communication and mobile telephony; digital governance; digital Identity; digital payments and benefits transfer; digital document storage and access.

¹https://static.mygov.in/rest/s3fs-public/mygov_158219311451553221.pdf

There have been more recent efforts to enable such leapfrogging and to lift the entire country in its journey to leverage technology.

1. IndEA 2.0 (India Ecosystem Architecture 2.0) is being developed as a new framework and an upgrade from the IndEA framework which was under the Digital India programme. It provides a generic framework comprising a set of architecture reference models, which can be converted into a Whole-of-Government Architecture for India, Ministries, States, Govt. Agencies etc. The IndEA framework is based on a federated architecture approach and recognises the need to accommodate both greenfield (new) and brownfield (existing/ legacy) e-Governance initiatives.
2. National Digital Health Mission (NDHM) was launched to provide the necessary support for the digital health infrastructure in the country, and the National Digital Health Blueprint provides an approach and a framework for the development of such digital infrastructure.
3. The education domain has experience with several initiatives:

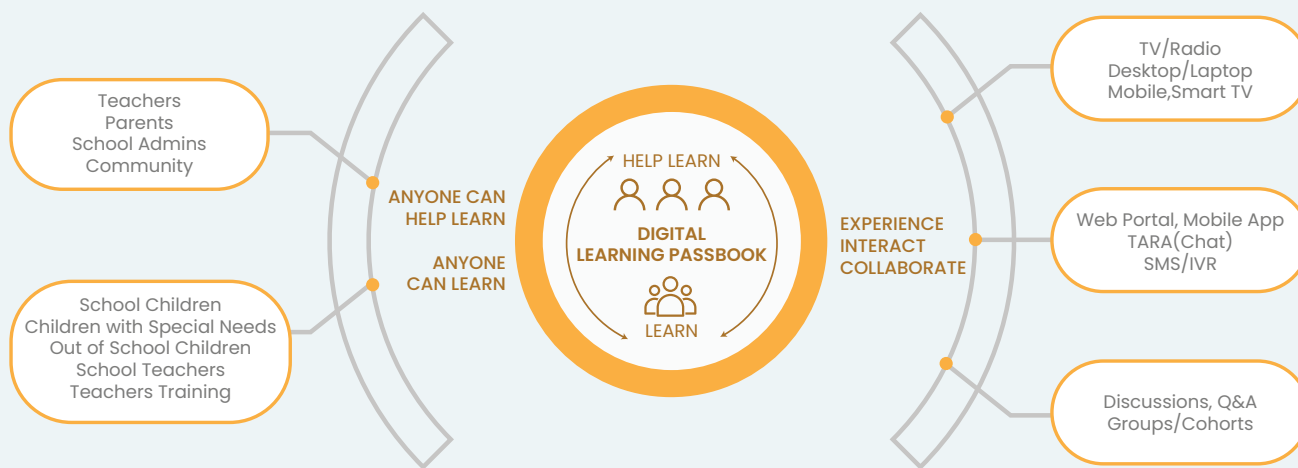
a. **DIKSHA** (Digital Infrastructure for Knowledge Sharing) is a national platform for school education, an initiative of the National Council for Education Research and Training (NCERT), MoE. DIKSHA was developed based on the core principles of open architecture, open access, open licensing, diversity, choice and autonomy as outlined in the *Strategy and Approach Paper* for the National Teacher Platform.² DIKSHA was launched by the Honourable Vice President of India, Shri Venkaiah Naidu, on Sept 5th, 2017 and has since been adopted by 35 States/ UTs across, as well as by CBSE, NCERT and crores of learners and teachers.³



- b. **SWAYAM** is a programme initiated by the Government of India and designed to achieve the three cardinal principles of education policy: access, equity and quality. This is done through a platform that facilitates hosting of all the courses, taught in classrooms from Class 9 till post-graduation. This can be accessed by anyone, anywhere, at any time. All the courses are interactive, prepared by the best teachers in the country and are available, free of cost to any learner.
- c. **UDISE+** is one of the largest Educational Management Information Systems in school education covering more than 1.5 million schools, 8.5 million teachers and 250 million children. It supports the collection of data, making it easier for the States and UTs to monitor the progress of the schools and to reduce the time taken in data collection and analysis.
- d. **PM eVidya** programme was announced in May 2020 with the objective to unify efforts across physical/ digital education & enable equitable multi-modal access, as shown in Figure 1 below.

²NTP – Strategy and Approach Paper, 2017

³India Report on Digital Education, 2020



ENABLING COHERENT MULTI CHANNEL, MULTIMODAL, LEARNING CONTINUUM

AT SCHOOL, AFTER SCHOOL, AT COMMUNITY CENTRE, AT HOME
 SYNCHRONOUS/ ASYNCHRONOUS, OFFLINE/ ONLINE,
 PHYSICAL/ DIGITAL, SELF-SERVICE/ ASSISTED

CONTENT
 Structured, curated, Shared across channels, NROER,
 NIOS, VidyaDaan, NCERT/ SCERT, NGOs, Private



HW/SW INFRA: Smartboards, Tablets, Live Conferencing, Hosting Infra, SMS, Email, Digilocker, JAM

CONNECTIVITY: Satellite, TV, DTH, Cable, Bharat Net, WiFi, Mobile Network

Figure 1: Enabling Coherent, Multi Channel, Multimodal, Learning Continuum⁴

For a listing of government initiatives, platforms and technology efforts in education across the country, see *India Report on Digital Education, 2020*. This does not include the diverse range of education technology solutions available in the private and non-government ecosystems, that cater to the K-12 spectrum in India, spanning across (but not limited to) after school tuition, assessments, lesson preparation, lesson delivery, teacher professional development, self-learning, homework, doubt resolution, parent participation and parent-teacher/ school communication solutions.

In the light of several new approaches and developments such as IndEA 2.0 framework, the goals set by the NEP 2020 and the diverse actors and capabilities of the Indian education ecosystem, it is time to develop a digital education architecture. This can be leveraged by States, education boards, ministries of education, non-profit and private sector institutions and the education technology sector, to support the delivery of the right to education for the learners of India.

1.2.3 Technology: A Powerful Energiser & Catalyst

In crafting NDEAR as the digital architecture for school education, there are experiences of several digital initiatives in the education domain in India to address the varied challenges and gaps identified over the years. These experiences and solutions can be built upon; it is not entirely unfamiliar nor a greenfield situation. The policy goals are clear and this is an opportunity to leverage technology in a manner that can help achieve these goals.

⁴Figure Source – India Report Digital Education 2020

As the digital architecture, NDEAR will provide a framework and a unifying structure for existing infrastructures, platforms and systems, for those which need to be created as per the NEP 2020, and also for solutions that the education ecosystem will develop. This architecture will give the education ecosystem the opportunity to innovate, amplify good innovations and solutions and address the needs of all learners and teachers including special, atypical and marginalised learners and teachers, and enhance the capability of existing applications.

In a large, diverse and federal education ecosystem, technology must play a positive and enabling role. It can support, supplement and amplify the efforts and inputs of its actors and stakeholders, particularly to support, enrich and enhance teaching-learning interactions and processes. The role of technology must be that of a supportive energiser and a catalyst to:

1. Enable Agency by providing Access and Choice

- a. To diverse solutions; teaching and learning content (e.g. differentiated instruction), practice content (expanding opportunities for practice), for learners with special needs and the differently-abled / atypical learners.
- b. To varied types and forms of assessments (for scale and efficiency).
- c. To Governments and other stakeholders; data analytics, data-driven policy making, value addition to existing systems.

2. Enhance Capabilities of Diverse Actors in the Education Ecosystem

- a. To use solutions.
- b. To create relevant digital content and solutions (e.g. in vernacular languages).
- c. To create and use unique IDs, Registries, MIS, geospatial capabilities, data visualisation and analytics, AI/ML based uses and solutions.

3. Catalyse Innovation to Improve Efficiency and Effectiveness of Learning and Administrative Solutions

- a. To provide access to solutions for learners with special needs (CWSN) and the differently-abled.
- b. Using tools and applications for whole school improvement and administration.

4. Improve Resilience of the System to Shocks and Disturbances

- a. Ensuring learning continuum for learners in school and out of school, across access points, devices, disruptions. Physical - digital connect and online/ offline access.

1.3 Scope : Vision – Objectives – Framework – Principles

NDEAR provides the framework, principles and overall structure for the development and creation of interoperable digital infrastructure, solutions and platforms for the education ecosystem. The scope of NDEAR is supportive of policy goals and the diverse education ecosystem. It provides the architecture for the development of digital infrastructure which is federated but interoperable, while ensuring autonomy of all the relevant stakeholders, especially States/UTs, and enables participation of the nonprofit and for-profit education ecosystem and not least, individual learners and teachers.

The NEP 2020 lays down several policy goals. It clearly states that “The highest priority of the education system will be to achieve universal foundational literacy and numeracy in primary school by 2025.” This is an important mission for the country and achieving this will need the combined and supportive capabilities of the education ecosystem, including but beyond the government systems.

A unifying digital infrastructure that supports the federal nature and structure of education will be of immense value to State governments across the country. It will avoid repeated expenditure on similar experiments in technology-related infrastructure across the country that would be common across diverse solutions, applicable across the lifecycle of learning for a student - from KG to PG. Further, it will catalyse innovation and increase the quality of education services in the education ecosystem. To do this, an understanding of the gaps and needs of the education system is needed, which must be a continuous process and not limited to looking at the current challenges and needs. If anything, the pandemic has emphasised the need for:

1. **Agile, resilient, efficient** systems to serve the needs of users and beneficiaries to suit their specific contexts, wherever they are.
2. **Federated** and decentralised systems (to reflect the federal nature of the education domain) in order to allow a plethora of solutions and innovations to emerge.
3. **Ecosystem approach** where actors (government, nonprofit and for-profit, and communities) can take necessary actions and provide **options** and **choices** to serve the needs of users and beneficiaries in the most effective manner locally.

While the number of actors in the ecosystem is vast, a simple categorisation could be: those who are **learners**, those who **help** others learn, and those who **administer** and manage the process of learn and help learn. Each of these actors has their distinct needs and need gaps.

The scope of NDEAR applies to the architecture of NDEAR in its entirety - its institutional structure, governance framework, technology and data. It is developed centrally for the benefit of users and beneficiaries, and due to the neutrality of the architecture, it has applicability at all levels of learning, early childhood to school and higher education, for instance:

A student Rui ...	A teacher Rima...
<ul style="list-style-type: none"> Started her schooling in Odisha and at the age of 8, her parents moved to Gujarat. Needs new school admission and to learn a new language. Needs to bridge learning gaps and language gaps. Needs assistance with transfer, admissions, fees, books, scholarships. Desires to acquire English and computer skills Wishes to pursue sports and arts Needs help with her learning journey across primary, secondary, high school and college. Needs evidence of achievements - report cards, marksheets and other credentials 	<ul style="list-style-type: none"> Needs to know the learning outcomes she has to achieve, the learning levels and gaps in her classroom. Needs to access resources that can help bridge learning and language gaps. Requires supplementary teaching materials, lesson plans and support for her diverse class when she needs it. Needs to know the learning outcomes and levels achieved by her students. Has to support her students and enable them to access diverse resources for their needs. Wishes to upgrade her skills and take courses at her pace and time; gain credentials to evidence her skills and growth Wants tools to reduce the burden of administrative tasks.

1.4 Vision of NDEAR

To be effective in the long term, NDEAR must have a learning and evolving core. The vision of NDEAR reflects this, both in its architecture and in its institutional framework.

VISION STATEMENT of NDEAR

*A globally pioneering effort in education - A unifying national digital infrastructure to **energise** and **catalyse** the education ecosystem*

NDEAR is federated, unbundled, interoperable, inclusive, accessible, evolving;

*which aims to create and deliver
diverse, relevant, contextual, innovative solutions
that benefit
students, teachers, parents, communities, administrators and
result in timely
implementation of policy goals*

1.4.1 Detailing the Vision Statement

1. **Digital Infrastructure** – A set of open-source components / building blocks that can be used to configure solutions of various kinds for the beneficiaries and users.
2. **Unifying** – A common framework of specifications, tools and protocols that enable different systems and organisations to connect with and leverage mutual strengths. Frameworks and specifications can be for domain-related matters and technologies.
3. **Energise and Catalyse** – Developing the frameworks, principles, policies, processes, standards, specifications and other activities to encourage and enable the education ecosystem to develop platforms, solutions and tools.
4. **Diverse Ecosystem** – Includes a range of actors and stakeholders in the education ecosystem such as Central and State/UT governments; School systems (government, private, formal, informal, alternative); Civil society organisations, community, private entities; Education experts, pedagogists, technologists; Learner, parent, teachers and school leadership.
5. **Federated** – Distributed and decentralised systems to preserve autonomy and agency of States, departments organisations and institutions. These systems must be interoperable through common standards and specifications, while maintaining their independence.
6. **Unbundled** – Building blocks and components that exist on their own and can be brought together to allow the creation of multiple solutions.
7. **Interoperable** – For systems to be able to connect with each other on a need-basis through open specifications and APIs. This includes interoperability (based on appropriate rules, administrative and legal frameworks) across systems and domains such as school education, higher education, health, child development, social justice, juvenile welfare, tribal welfare, minority affairs and others.
8. **Evolving** – Learning objectives and needs evolve with changing times; technology evolves as well. Therefore, NDEAR must be an evolutionary system for the future and not limited to addressing systemic challenges identified in the present.
9. **Policy Goals** – SDGs, NEP – 2020, ECCE, Foundational Literacy and Numeracy Mission (FLN), PM eVidya.

1.4.2 Understanding NDEAR

NDEAR is	NDEAR is not
<ol style="list-style-type: none"> 1. An architectural blueprint for the education ecosystem and not a system. 2. That defines a set of <ol style="list-style-type: none"> a. Principles – e.g. technology and ecosystem b. Standards and Specifications – e.g. technology and data c. Guidelines – e.g. data process, ecosystem engagement d. Policies – e.g. data, openness, inclusion, accessibility 3. And identifies the key building blocks needed to make the architecture blueprint a reality 4. For an ecosystem of <ol style="list-style-type: none"> a. Actors to build, develop, innovate – interoperable building blocks b. Applications/Innovations in the form of Solutions, platforms, tools, assets to be developed and used 5. To enable the achievement of policy goals through programmes such as – SSA, FLN Mission – etc 	<ol style="list-style-type: none"> 1. A monolith platform; or 2. Portal; or 3. Application; or 4. A mobile app; or 5. An entity; or 6. Software component(s); or 7. Prescriptive set of: <ol style="list-style-type: none"> a. Features Solutions b. Education policies & programmes. It is not a builder or developer of building blocks, solutions and programmes

1.5 Objectives of NDEAR

The objectives of NDEAR, reflecting its vision statement would be to:

1.5.1 Catalyse the Education Ecosystem

- *Build, sustain and evolve digital infrastructure by:*

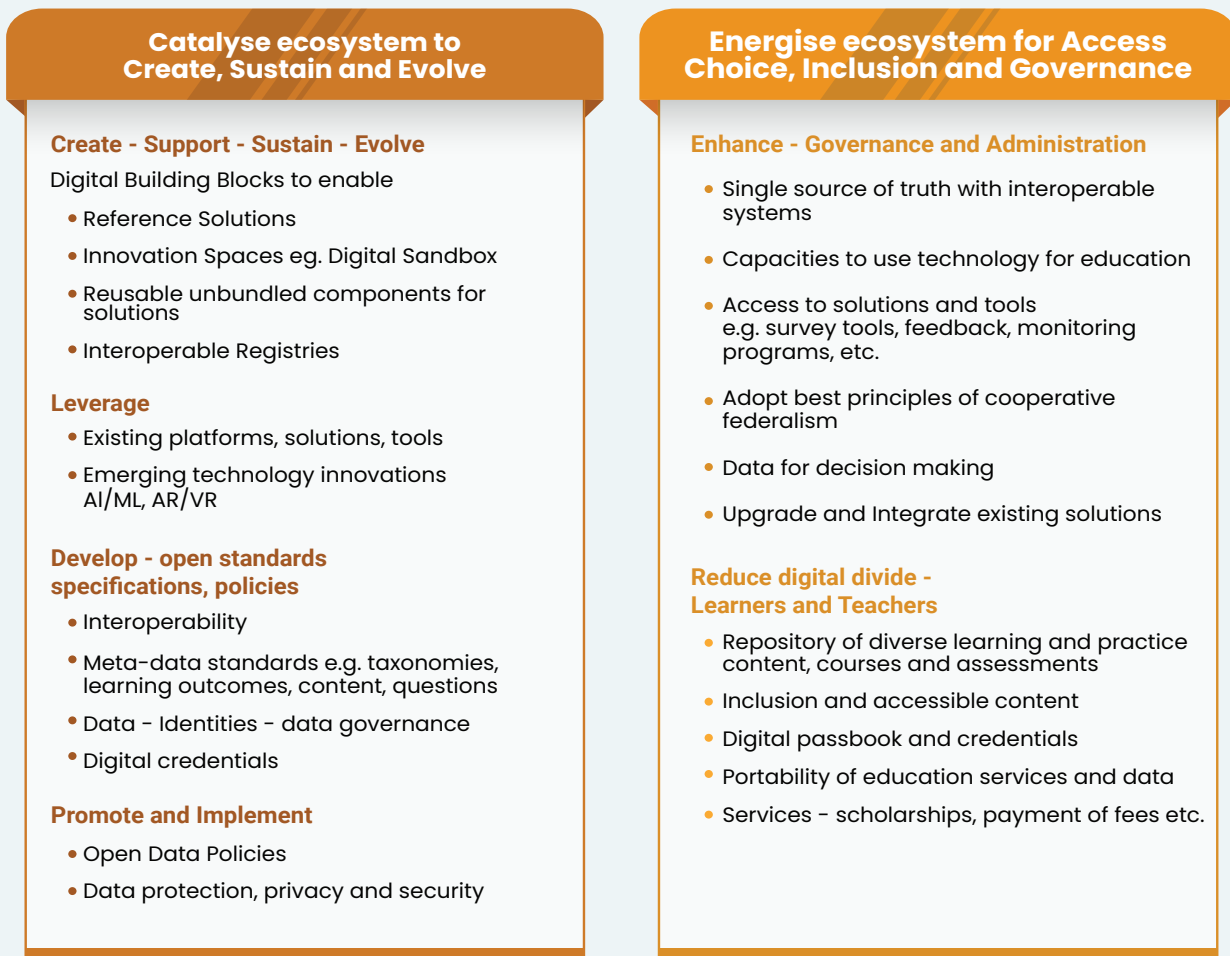
1. Creating and supporting the creation of “Digital Building Blocks” – a set of core capabilities for the education ecosystem, enabled through independently reusable components or services, and a set of reference applications and tools. Digital building blocks enable the following:
 - a. A set of reference solutions such as DIKSHA, SWAYAM etc that are freely available for the education ecosystem to use.
 - b. A set of reusable, unbundled services/components enabling the ecosystem to create decentralised solutions to cater to diverse contextual needs of users, including users with special needs (eg. children with special needs (CWSN)/ differently-abled/ atypical requirements).
 - c. A set of interoperable, secure electronic registries such as UDISE+ for managing master data and people/entity data as a single source of truth.
 - d. A set of national open standards for promoting interoperability and portability.
 - e. Innovation spaces via ecosystem sandboxes, transparent rules, a set of enabling tools, and co-creation environments.
 - f. Seamless interoperability of all the above; functioning in a federated, decentralised manner across Centre, State, boards and school levels.
2. Developing and Evolving:
 - a. Open standards, specifications and policies for digital infrastructure and interoperability, data, digital credentials etc.
 - b. Identity architecture & data governance frameworks for individuals and institutions.
 - c. Meta-data standards (machine-readable, interoperable) for representing the core elements of education: taxonomies, learning outcomes, pedagogies, content, questions, marks, credentials/certificates, accessibility, data of individuals and institutions.
3. Leveraging:
 - a. Existing and planned platforms, solutions, applications tools, assets; harmonise and make them interoperable. e.g. UDISE ++
4. Evaluating and promoting:
 - a. New and emerging technology innovations like AI/ML, AR/VR, conversation interfaces, haptic feedback technologies, etc.
5. Promoting, implementing and sharing:
 - a. Open data policies. Make open data publicly available as data sets and encourage the use of open anonymised data for data based planning, decision making, analytics and research.
 - b. Best practices in data protection, privacy and security; collection of data for clear end-use and purpose; develop and follow consent architecture; data access protocols that respect and protect individuals against undue oversight and monitoring. To particularly secure the digital rights, privacy and protection of children against tracking, tracing and monitoring, that could result in harm and discrimination.

1.5.2 Energise Various “Ecosystem Actors”

Actors will use and derive value from the digital infrastructure to:

1. Ensure equitable access, choice, convenience and inclusion and reduce the digital divide for learners and teachers by:
 - a. Enabling access to contextual and relevant teaching and learning content and materials to address diverse needs across the country, e.g. make available a repository of high-quality resources on foundational literacy and numeracy on DIKSHA.
 - b. Ensuring and promoting inclusion and accessibility across languages, geographic areas and abilities. To promote the development of learning and teaching content, solutions and tools for atypical learners with special needs and the differently-abled.
 - c. Enabling convenient access to educational services like scholarships, payment of fees, obtaining certificates in an online and seamless mode.
 - d. Enabling free, convenient access to high-quality practice materials and e-assessments.
 - e. Enable national portability in the provision of education services and data.
 - f. Allowing individuals, teachers and even students to create and contribute content and be recognised.
 - g. The flexible, yet continuous personalised learning journey for learners e.g. with digital credentials and digital learning passbooks, 360-degree feedback, personalisation of content, language, formats, pedagogies.
2. Enhance good governance and administration of education by:
 - a. Enabling a single source of truth with interoperable systems e.g registries and generation of trusted open data for research and improvement of programmes and initiatives.
 - b. Enhancing the capacities of learners, educators and administrators in using technology for education. E.g. for learners and teachers, anytime - anywhere learning; for teachers and administrators, to carry out large scale sample surveys on key competencies.
 - c. Enhancing the efficiency and effectiveness of education administration with effective solutions and tools for education administrators, resulting in good governance. E.g. tools for surveys and feedback, monitoring and tracking of government funded programmes; to ensure 100% enrollment of learners.
 - d. Adopting the best principles of cooperative federalism while working with the States and UTs for the realisation of the vision - institutionally and technologically.
 - e. Allowing upgradation, integration and consolidation of their various applications, systems as and when each State, board or administrative unit wants.

Figure 2: Objectives of NDEAR
Digital Infrastructure for the Education Ecosystem



1.6 Framework for NDEAR

In keeping with the vision and objectives for NDEAR, the framework for NDEAR has the below six elements.

1. Focus on beneficiaries and users.
2. To energise and catalyse the diverse ecosystem to innovate and evolve.
3. Through a unifying and evolving architecture.
4. Powered by open data while protecting identities.
5. Supported by a sustainable institutional framework.
6. With a time-bound implementation plan.

The NDEAR framework would need to be applied to develop platform, solutions and tools for:

- **5 key personas - learners, parents, teachers, administrators, community members.** The term personas mentioned here refers to roles played by different people. The term teacher means anyone who is helping a learner learn. Likewise, the term learner would apply to all learners young and adult, for instance, it would include a teacher who is learning by undertaking a course. Community members refer to any individual or institution. The term administrator refers to anyone who is involved in the management of the learning process, be it in government or other sectors (e.g. a private/NGO run schools). The term parent would include guardians and caregiving individuals in the life of a minor.

- **3 Ecosystems - Programmes - Assets - Solutions.** The ecosystems here are in the domains of creation and implementation of programmes, creation of solutions and development of assets. The term ecosystem refers to government/government agencies; non-profit as well as profit organisations.
- **3 Generalised Scenarios - Learn - Help Learn - Manage Learn.** At the core of the whole education ecosystem, three main scenarios play out. They are learning, helping the learning process and managing the learning process, in order to achieve learning outcomes. Therefore, digital infrastructure and architecture should focus on the development of solutions for these scenarios.
- **2 Key Interaction Categories** - Learning Interactions - Administrative Interactions.



Figure 3: NDEAR – High Level Functional Architecture
(to be deployed as a set of interoperable federated systems)

1.7. Principles for NDEAR

The principles for each of the six elements of the NDEAR framework are outlined below:

1.7.1. Focus on Beneficiaries and Users

The interests of the beneficiaries and users for whose benefit the digital infrastructure and solutions will be developed must be a central focus. Depending on context and solution, beneficiaries and users would be the learners, teachers, parents, school leaders, administrators (government and private) and community members. In developing digital infrastructure for learning, beneficiaries and users need to be understood continuously.

Principles to be followed:

1. User-Centric Design

- a. In the development of infrastructure and solutions
- b. Application of principles of universal design for learning to support greater inclusion

2. Affordance, Choice, Agency

- a. Diversity of solutions (e.g. localised content in local languages)
- b. Multimodal coherent access (across mobile devices, computers, broadcast media - TV and radio)
- c. Enabling a learning continuum

3. Open Access

- a. Anytime, anywhere
- b. Anyone (can learn, help learn and manage learning process)
- c. Formal or informal or alternative (e.g. learning spaces for the differently-abled and atypical learners with special needs)

4. Diversity and Inclusion

- a. Linguistic
- b. Geography
- c. Across device types
- d. Offline/online access
- e. Across the spectrum of special needs, learning difficulties, differently-abled
- f. Accessibility compliant

1.7.2. Ecosystem Approach – Participation, Collaboration, Contribution

In the context of India, it is necessary to define the architecture for creating a framework for the evolution of an Education “Ecosystem” – and NOT a “System”. This has been echoed in other digital missions of the Government of India as well. For instance, the National Digital Health Blueprint states,

An ecosystem cannot be built, nor can it evolve on a prescriptive approach. Hence the Blueprint proposes to be evolved on the basis of a set of commonly believed principles, which again, pertain to the business (i.e. the Health Domain) and technology. The governments, central and state, must play the role of facilitators, enablers and advocates of these principles to speed up the evolution of the National Digital Health Eco-system.⁵

No single application, portal, technology can address India’s education challenges. Energising the ecosystem is necessary to bring in innovation, diversity, and contextualisation. Participation, collaboration, and contribution are key factors in fostering an educational ecosystem that delivers effective education. The education ecosystem will only flourish, thrive, grow and evolve in a participative and collaborative environment where various stakeholders and actors can easily leverage and freely contribute to the ecosystem.

⁵National Digital Health Blueprint, circulated as of 8th Nov 2019.



Figure 4: Diverse Ecosystem

1. Role vis-a-vis ecosystem: Ecosystems evolve and thrive in open supportive environments. They cannot be built; they emerge organically and grow in the right environment and conditions. To this end, NDEAR must:
 - a. Catalyse
 - i. Innovation, experimentation and contextualisation.
 - ii. Diversity, inclusion and address special needs.
 - b. Energise across
 - i. Actors - Government + Civil Society (communities and individuals) + Markets.
 - ii. Geographical levels: Centre → State → District → Block → School.
 - iii. Actions - Use, deploy, configure, innovate customise, extend, build, contribute.
 - iv. Applications - solutions, infra, assets and programmes.
 - c. Support
 - i. Policies for ecosystem evolution
 - ii. Infrastructure development
2. Types of Ecosystems - The large, complex and diverse education system, with its myriad challenges needs contextual solutions. This is only possible if the vibrant ecosystem is able to operate and deliver relevant and necessary assets, programmes and solutions to serve the needs of beneficiaries and users. NDEAR must support three types of ecosystems across government, non-profit and private sectors:

Programme Ecosystem	e.g. Samagra Shiksha, Prabandh, Vidyanjali, Dhruv, FLN Mission, PM eVidya, ECCE and several State level programmes (e.g. CM Rise in Madhya Pradesh, Mission Prerana in Uttar Pradesh and others/ private programme initiatives/ non-profit programme initiatives).
Asset Ecosystem	Content, collections, taxonomies, courses - by government, non-profit, private, experts, individuals.
Solution Ecosystem	<ul style="list-style-type: none"> -Solutions and tools focused on languages, FLN, teacher professional development, sourcing of content, the differently-abled and special needs. -Solutions developed using APIs or plug-in through APIs. -Solutions by government, non-profit and private sector.

3. Principles for energising and catalysing the ecosystem
 - a. Openness in access and licensing, standards and specifications.
 - b. Focus on the needs of beneficiaries and users.
 - c. Energise Innovation: Innovation should be encouraged, acknowledged and rewarded.
 - d. Curation and Regulation: Continuous curation of resources and appropriate regulation of processes and stakeholders.
 - e. The ecosystem must have agency: Agency helps bring in specialised skills and efficiencies in the implementation of programmes/interventions.
 - f. Take care of diversity, inclusion and special needs: The learning ecosystem should cater to the diverse languages/mediums of instruction as well as to children with special needs (CWSN).
 - g. Make it easy: Manage performance and interventions in a non-intrusive manner.
 - h. Respond resiliently to systemic shocks: The COVID-19 pandemic has starkly brought out the need to design delivery models which are flexible to adapt to different scenarios, including emergencies and disasters, at a local, regional and national level.
 - i. Leverage ecosystem economics: Data emitted from programmes should be used as input in policy making and decision making.

1.7.3. Open Data, Data Empowerment and Protection

Digital architecture is incomplete without principles to govern data. In NDEAR, data will be required to improve solutions, policies and programmes. In addition, given the users and user interactions, data of individuals and particularly children will have to be addressed with exceptional care.

1. Open Data for evolvability of solutions and policies.
2. 'Emit' (vs 'Extract') of data streams from usage, user interactions and outcomes.
3. Follow open data policies in the interest of transparency and evolution.
4. Data empowerment and protection of individuals privacy and confidentiality.
5. Privacy by Design: Privacy of beneficiaries of the platform is of utmost importance, and special care must be taken with regards to the data of children.
6. Personally Identifiable Information (PII) and data collection must be minimal, limited, used for stated specific purposes and must be non-intrusive.
7. Consent architecture must be developed and strictly followed. Particular attention must be made to the design of technology and processes for clear and explicit consent. Special attention should be paid to ensuring the protection of children and seeking correct and appropriate consent for specific engagements and actions from parents and guardians. Sweeping, generalised consent processes, practices, terms and design must be discouraged.
8. Users must have appropriate access, control and visibility to their personal data.
9. Protection of Children: Children must be protected against identity tracing, tracking, labelling and discrimination. Protecting their privacy and confidentiality of their performance and personally identifiable data must be of paramount importance.

Rights of Children⁶ : In a digital world, where their actions and interactions could impact them into adulthood, the duty to protect children is that of governments, private organisations and civil society

1. Children have the right to privacy and the protection of their personal data.
2. Children have the right to freedom of expression and access to information from a diversity of sources.
3. Children have the right not to be subjected to attacks on their reputation.
4. Children’s privacy and freedom of expression should be protected and respected in accordance with their evolving capacities.
5. Children have the right to access remedies for violations and abuses of their rights to privacy and free expression, and attacks on their reputation.

10. Data Lifecycle: Entry, Storage, Usage, Control, Retention and Deletion

- a. Single entry for a data record – avoid inefficient duplication of effort.
- b. Single source of truth.
- c. Accountable access, distribution and storage of data.
- d. Federated control structures.
- e. Integrated visibility of data for policy evolution.
- f. Lifecycle of data from generation – storage – deletion

1.7.4. Design and Architecture Principles: Unifying and Evolving

These principles of architecture would be relevant for technology as well as institutional design and may be viewed in that context, for **scale, diversity, complexity**.

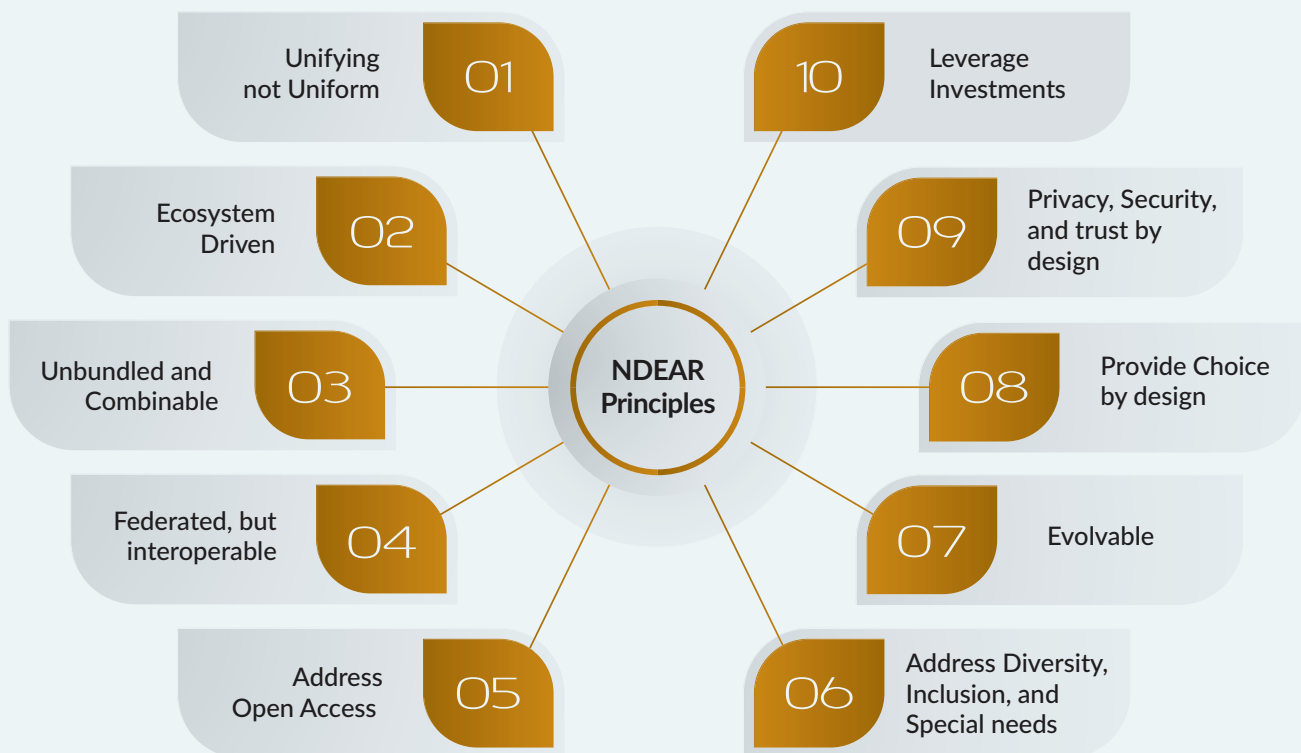


Figure 5: NDEAR Principles: A Unifying and Evolving Design

⁶UNICEF - [https://www.unicef.org/csr/files/UNICEF_Childrens_Online_Privacy_and_Freedom_of_Expression\(1\).pdf](https://www.unicef.org/csr/files/UNICEF_Childrens_Online_Privacy_and_Freedom_of_Expression(1).pdf)

India’s data protection bill and laws related to the protection of children contain principles that must be applied in the digital context as well. Children have to be protected from tracking, tracing and in the context of education, labelling and discrimination.

1	Unifying not uniform	India's diversity must be retained and unified in a coherent way for the amplification of efforts by all actors.
2	Ecosystem driven	No single app/portal/technology can solve India's education issues. Energising the ecosystem across governments, society and market players is necessary to bring in innovation, diversity, contextualisation and choice. Continuously engaging the ecosystem through transparent rules and a set of relevant tools is key to harnessing the energy of the ecosystem actors.
3	Unbundled and combinable	Instead of focusing purely on "solutions", build underlying unbundled building blocks to allow diverse solutioning by the ecosystem. Fully pre-built systems cannot evolve and allow for diverse solution needs. All aspects of NDEAR must be built as unbundled microservices offered via APIs that are interoperable and can be combined to build newer solutions.
4	Federated, but interoperable	While a central system can speed up adoption, it should be a choice, and bringing interoperability across many federated systems through common specifications is necessary.
5	Address open access	Anyone can learn, anyone can help learn, anyone can support and administer. Open license and open-source policies are key.
6	Address diversity, inclusion, and special needs	Design to cater to diversity across language, context, device, connectivity, capacity, etc., and ensure the system addresses users with special needs, with relevant tools and content. The system shall provide uniform access to everyone, including those in remote areas, with limited or no connectivity, and support the end point devices at the root level.
7	Evolvable	Design must allow the entire infrastructure to evolve and adapt on a continuous basis without needing dramatic upgrades.
8	Provide choice by design	Design to allow choice for actors (States, boards, schools, teachers, students, etc.) with respect to choice of apps, choice of usage within their context, etc.
9	Privacy, security and trust by design	Design to protect privacy and data of users and entities and imbue trust in every interaction.
10	Leverage investments	With respect to existing systems at various administrative levels (Centre, State, and school), it is essential that they be leveraged by upgrading them as per NDEAR architecture principles, integrating them with other NDEAR building blocks, and when necessary consolidating them into unified platforms. This is essential to provide simpler, coherent, and unified experiences to key stakeholders and also to bring them in line with NDEAR.

1.8. ICT Infrastructure

The success of NDEAR and its ability to generate diverse solutions which are leveraged by the various personas in the education ecosystem will, in general, require the availability of ICT infrastructure as well as PHYGITAL (physical – digital) solutions. NDEAR must engage with and connect with efforts in the country to ensure access to ICT infrastructure as well as low-cost access to devices.

1.9. Measurability

The NDEAR institutional structure (detailed in the Institutionalisation chapter) must define frameworks and metrics to measure (including but not limited to) the following aspects, in order to assess the impact of NDEAR:

1. Adoption of NDEAR.
2. NDEAR compliant and compatible solutions.
3. Reach of NDEAR.
4. Impact of NDEAR on learning outcomes.
5. Standards developed for openness and protection of learners, data protection and privacy.

In addition, such measurements must take into account other relevant recommendations such as IndEA 1.0 / IndEA 2.0

2.1. Overview

The NEP 2020 has defined the vision of 'education for all'. Continuum of services is a concept strongly advocated by the NEP 2020. These policy goals are sought to be achieved by refactoring the existing schemes and introducing several new schemes including some digital initiatives.

NEP 2020 clearly states the need for an open digital infrastructure:

There is a need to invest in the 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. (Para 23.4.b, page 59)

NDEAR envisions digital infrastructure for school education that allows all ecosystem actors across government, civil society, and market players to build and innovate platforms, solutions and tools that are compatible or compliant with NDEAR. The core of NDEAR provides the following:

1. **Specifications & Standards:** A set of nationally interoperable standards and specifications allowing interoperability and portability across all systems.
2. **Microservices & APIs:** A set of unbundled services deployed in a federated manner and available via APIs, which can be used by the ecosystem to build and innovate solutions to address the diversity and scale.
3. **Reference Solutions:** A set of reference solutions and apps that can be deployed in a federated manner and used freely out of the box by students, teachers, parents, administrators, and community members.

To cater to 5 key persons and 3 key ecosystems across 2 core interactions. Refer to **Figure 3 : NDEAR - High level Functional Architecture** in the scope section of this report.

All these aspirations can be realised principally by leveraging the power of digital technologies. In the context of India, with its size and diversity, this mammoth task requires that a holistic, comprehensive and interoperable digital architecture is crafted and adopted by all the stakeholders. In the absence of such architecture, the use of technology in the education sector will continue to grow in an uneven manner and in silos.

Eco-System, not System!

To cater to the diversity and scale of India, it is necessary to define the architecture for creating a framework for the continuous evolution and innovation within the Education domain – an "Ecosystem" and NOT a "System"!

The architecture keeps the overall vision of NEP 2020, SDG 4 and India Enterprise Architecture in perspective and recommends a pragmatic agenda to start with, adopting the principle of 'Think Big, Start Small, and Scale Fast'. It has been designed as a layered framework using building blocks and surrounded by standards and regulations and common technology stack.

Education ecosystems comprise loose networks of multiple stakeholders like students, teachers, formal and non-formal schools, Central & State governments, autonomous bodies, school management bodies, societies, Trusts, open schools, tribal schools, sports schools, technology providers, agencies of related products and services. An ecosystem cannot be built or evolve on a prescriptive approach. NDEAR architecture proposes an evolving ecosystem – across programme, asset, and solutions categories – based on a set of common ecosystem principles. It is essential that the rules of participation be made transparent, simple, and easy to ensure that the entire ecosystem can participate.

In addition to using various reference solutions such as DIKSHA mobile app & portal, UDISE+ portal, etc. available within NDEAR, ecosystem partners may build their own solutions and make them available in the market to provide a wider choice to students, parents, teachers, schools, states, and education boards.

2.2. Existing Technology Landscape

Digital technologies have proliferated in school education, and its outreach is continuously increasing. Digital technologies are enabling students, teachers and administrators to impart quality education and overcome the challenges in school education.

An overview of the government-led education technology landscape (indicative, not a complete list) is shown below along with the India Stack Infrastructure.

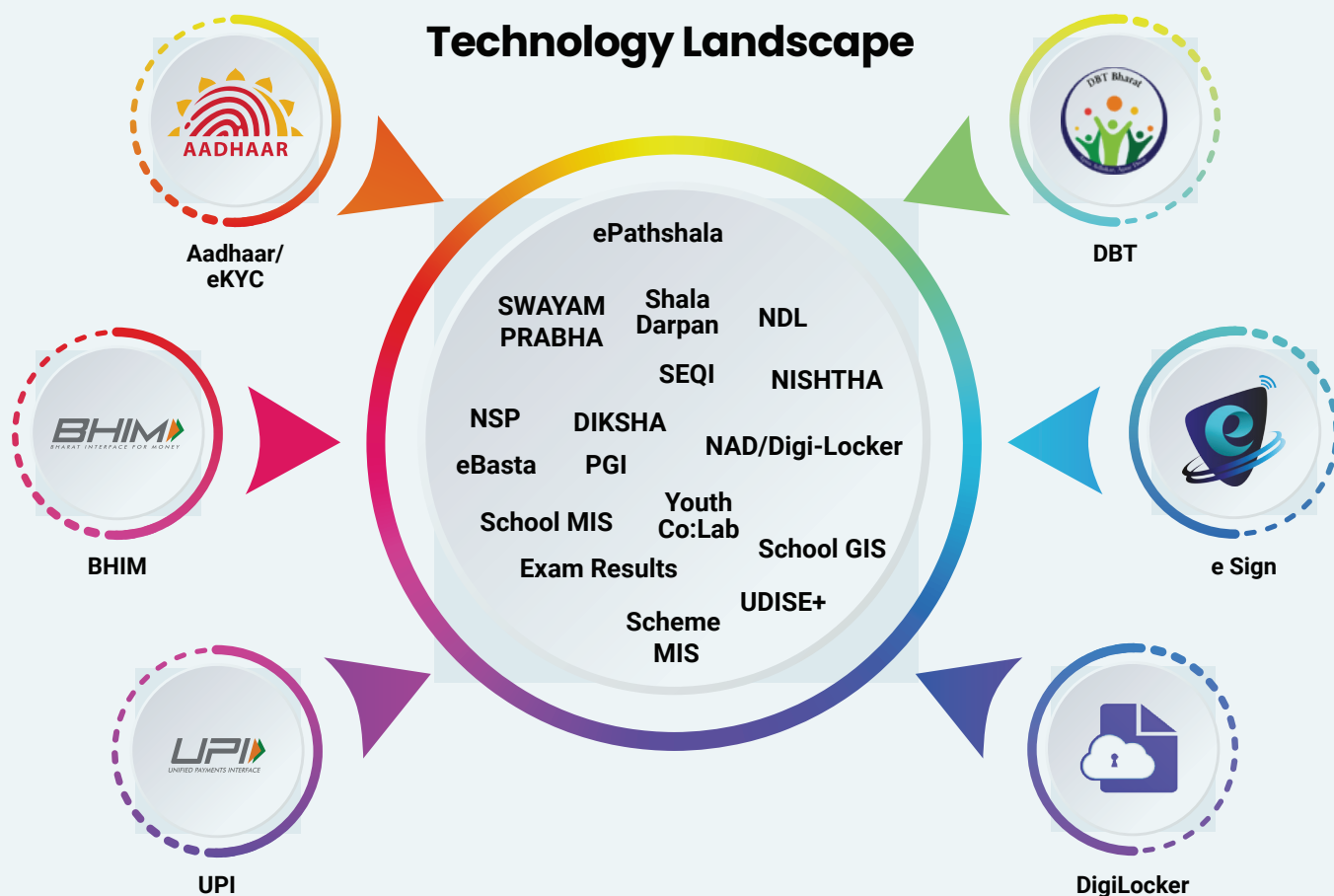


Figure 6 : School Education Technology Landscape (indicative) Built on India Stack

It is essential that many of the government-led education technology solutions are integrated, upgraded, and consolidated to fully leverage existing investments. This is essential to ensure students, teachers, and other users get a simpler and unified experience instead of a siloed set of applications and platforms. An indicative list of applications/portals in the education domain is available in Annexure 2.

2.3. NDEAR Architecture Principles

The Principles of NDEAR architecture are stated and briefly explained in the Table below:

2.3.1. Technology Architecture Principles

The governments, Central and State, must play the role of facilitators, enablers and advocates of these principles to speed up the evolution of the National Digital Education Ecosystem.

S.N.	Principle	Description
A1	Adopt India Enterprise Architecture (IndEA) framework	The artefacts prescribed by the IndEA Standard will be prioritised and sequenced. The design of the building blocks of NDEAR will adopt and conform to IndEA by default. Other national and international standards will be adopted in areas not covered by IndEA. NDEAR shall adopt the latest version of the India Enterprise Architecture (2.0) Framework or any other appropriate framework at the appropriate time.
A2	Built on open-source, built as open-source, and using open standards	All services (except which are notified as sensitive) built into the digital infrastructure (core of NDEAR) should be based on and built as open source, whenever possible, ensuring vendor neutrality, transparency, and strategic control of the core digital infrastructure. Applications that are built aligned with NDEAR may choose to use non-Open-Source Software, especially when these applications are built outside the Government (private school apps, etc). In addition, open international and national standards should be adopted when available and new standards should be created, when necessary, to ensure interoperability and portability. Open standards and specifications must also be regularly upgraded, new specifications introduced as open source using experts from the community.
A3	Portable	Design for portability of data, certificates, credentials, documents, content, etc. based on open standards.
A4	Scalable	All technology services and processes that are part of NDEAR must be designed for operating at the intended scale (be at country scale or State or local scale). Extreme automation, distributed human processes etc. are key aspects for overall system scale and manageability.
A5	Resilient	Services that are part of NDEAR must be built to withstand failures by building automated recoveries and adaptation. Similarly, all processes established as part of NDEAR must be designed to allow flexibility and re-adaptation to handle disruptions.
A6	Interoperable via open APIs and standards	Design interoperability via open APIs and open standards to support federated design principles, so that various solutions built by the ecosystem are able to work in a unified manner.
A7	Use of emerging technologies	NDEAR should be architected to leverage various technology innovations as and when they become viable and useful to improve education.

A8	Open Data and Observability via “data emit”	By design, NDEAR services must be built to emit anonymised telemetry events for generating aggregate open data, understanding system behaviour, supporting policy evolution, etc. Multiple data entries and time consuming data extractions etc. must be eliminated. All such open data must be made available as “public good” for access by all for enhancing research, interventions, policies, solutions, and overall understanding of the effectiveness of the education system as per <i>National Data Sharing and Accessibility Policy</i> . ⁷
A9	Minimal, reusable, unbundled microservices	Core NDEAR services must be minimal (both data and functional minimalism), atomic, and generalised, allowing solution builders to “reuse and extend” them to build contextual solutions. All services that are part of NDEAR are to be designed in a “ <i>generalised</i> ” manner to allow diverse use cases to be built on the same set of services. These generalised services must “ <i>externalise</i> ” its configurability and expose various configurations within the API itself to allow solution building across diverse contexts.
A10	Security, Privacy, Trust, Data Empowerment by Design	Security of services and data should be designed into all blocks of NDEAR using strong security design principles. Security should be baked into all aspects of a digital system. All solutions and services within NDEAR must adhere to appropriate data protection and privacy laws.
A11	Registries and Master codes as Single Source of Truth	Considering NDEAR being a federated architecture with decentralised systems and applications, for interoperability and unification, it is essential that various master codes and decentralised electronic registries are established and made available via common APIs. The discovery of decentralised services and registries also need meta registries (registry of registries or service discovery registry) and should be designed into the architecture.
A12	Evolvable	NDEAR architecture and the building blocks of the digital infrastructure should not be thought of as a one-time exercise, rather, an evolving construct. Given the large and diverse ecosystem of actors and applications, it necessitates all NDEAR building blocks to be clearly versioned, backward-compatible, and have well-defined and transparent version retirement policies. This is to ensure that various applications/systems depending on NDEAR can adopt and upgrade asynchronously at their pace and evolve along.

2.4 Federated Architecture and Building Blocks

Digital technologies are playing an important role in school education today. NDEAR provides an approach to establish a “Federated Architecture”, defined in terms of its building blocks. The federated architecture approach seeks to enable the education ecosystem by streamlining information flows across players in the ecosystem, while keeping student/ teacher, their privacy and confidentiality of data at the forefront. A good design can help accelerate the adoption and improve the delivery of education services across both the public and private sectors, while also addressing the digital divide through innovative integrated solutions across digital-physical contexts. NDEAR identifies key building blocks by looking at the most common requirements of the overall education ecosystem.

2.4.1 Federated Architecture

Federated architecture (FA) is a pattern in enterprise architecture that allows interoperability and information sharing between semi-autonomous, de-centrally organised entities, information technology systems and applications. For ensuring the security and privacy of personal and sensitive information of students/ teachers, while ensuring interoperability, technological flexibility and independence, the federated architectural pattern in NDEAR is essential. Such an architectural pattern is also ideally suited to the conditions prevalent in a federal set up like India, and includes both public and private institutions.

⁷See <https://dst.gov.in/national-data-sharing-and-accessibility-policy-0>

1. Principles

The federated architecture presented here is based on a set of principles below, which are not prescriptive, but suggestive.

- a. All NDEAR services, data, and applications are held at multiple levels – say national, State and local levels – in a decentralised manner, following the principle of minimalism at each level.
- b. A set of interoperable electronic registries at the appropriate level (national, State, school) will be enabled based on a common registry schema that allows seamless information interchange between various systems (with consent from individuals as necessary).
- c. School ID shall be generated as part of the national registry but the control of data and attributes will be decentralised to State or district or school levels, as appropriate.
- d. All schools that are part of the NDEAR ecosystem will be part of the national registry, with unique IDs for bringing higher levels of trust, transparency, and master data interoperability.
- e. Student and teacher registries will be held at the school level, school management level and state level, as appropriate. Student and teacher registries will not be held at the national level. Non-PII metadata can be stored at the national level for analytics and open data purposes.
- f. Students/ parents/ teachers shall be in full control of their “educational data records” as per data empowerment principles in a machine-readable, digitally-signed, printable, and portable manner.
- g. Systems-of-Records (SoRs) shall hold the primary data to ensure a single source of truth; all other IT systems, applications or entities will have access to it only through APIs, subject to the applicable permissions and consents.
- h. Granular consent shall be required for data sharing, following the principle of purpose limitation. Parental consent shall be adopted for minors. Access to any personal data (data containing PII) enabled through NDEAR services will only be possible via electronic consents.
- i. Central and State education departments, autonomous bodies, school boards, private educational school societies etc. having capacity/ infrastructure shall be data fiduciaries.
- j. The data fiduciary managing the data and the data processor holding and processing the same shall be responsible for the data protection obligations and compliances under the applicable laws.

To cater to the diversity of contexts in India, ecosystem partners will be encouraged to use, contribute, and extend NDEAR solutions through clearly defined ecosystem policies, rules, and tools.

Following are an indicative set of principles of governance of federated architecture:

1. Federated Architecture (FA) operates collaboratively where governance is divided between a central authority and constituent units, balancing organisational autonomy with enterprise needs.
2. The Central Authority's architecture can focus on the dynamics of economies of scale, standards, interoperability and the common requirements, while the constituent units' (States and schools) architectures have the flexibility to pursue autonomous strategies and independent processes.
3. Participating members can jointly agree upon the common goals and governance of the federation which are expressed by the policies governing the roles and responsibilities of membership, resource discovery, and resource access.
4. There is an administration role whereby federation membership, resource discovery, and resource access can be granted or revoked according to governance policy.
5. States and schools can participate in a federation by selectively making some of their resources discoverable and accessible by other federation members.

6. While the purpose of a federation is to collaborate and share resources, resource owners retain ultimate control over their own resources.
7. The design of all the systems in the federation shall conform to the prevalent laws and regulations relating to security, privacy and data-sharing.

2. Salient features of the federated architecture

The following are the salient features of the architecture:

- a. The federated architecture is indicative. It can be modified, enhanced and evolved with time.
- b. The federated architecture is modular in nature. The combination of modules necessary at each level/ setting will be decided while designing the information systems.
- c. The architecture is laid out at 3 administrative levels - national, State/ UT/ Board and local (school/ student) Levels.
- d. Each administrative level may have one or more building blocks representing key interactions. (See Figure 7).
- e. The 36 building blocks within 12 categories across 3 administrative levels are loosely coupled on a 'need-to-connect' basis, using standardised API's and open specifications. The principles laid out within NDEAR are applied at each level and layer, and in the design of these building blocks.
- f. To ensure data consistency, interoperability and national portability, only the minimum required number of building blocks are designed, developed, open sourced, held and managed centrally.
- g. Open interoperable standards, specifications, and protocols are developed in a collaborative manner, and maintained at the national level to ensure national interoperability and portability.
- h. "Reference Applications" at various levels should be designed and developed as reusable, multi-tenant, open-source and standards-compliant applications, made available to all via open-source repositories, websites, and/or app stores.
- i. Data shall be maintained at different levels where data is generated called the "System of Record (SoR)". All the technology requirements, legal data protection and empowerment aspects, and specifications of data shall be supported appropriately within each SoR. It may be observed that each education data type (including master and transaction data) is maintained at one level only within an SoR (be at Central or State or school level), to ensure uniqueness and consistency. For instance, a student's education record is maintained by the school level and is made available digitally through local or national lockers, where such data links can be maintained. All user data should be in the control of the user and made portable as per Data Empowerment (DEPA) principles in accordance with the Personal Data Protection bill.
- j. A repository of standards and master codes shall be maintained at the national level as electronic registries with open APIs, for various systems to integrate. All registries shall conform to well documented, standard search/ access APIs with published schemas.

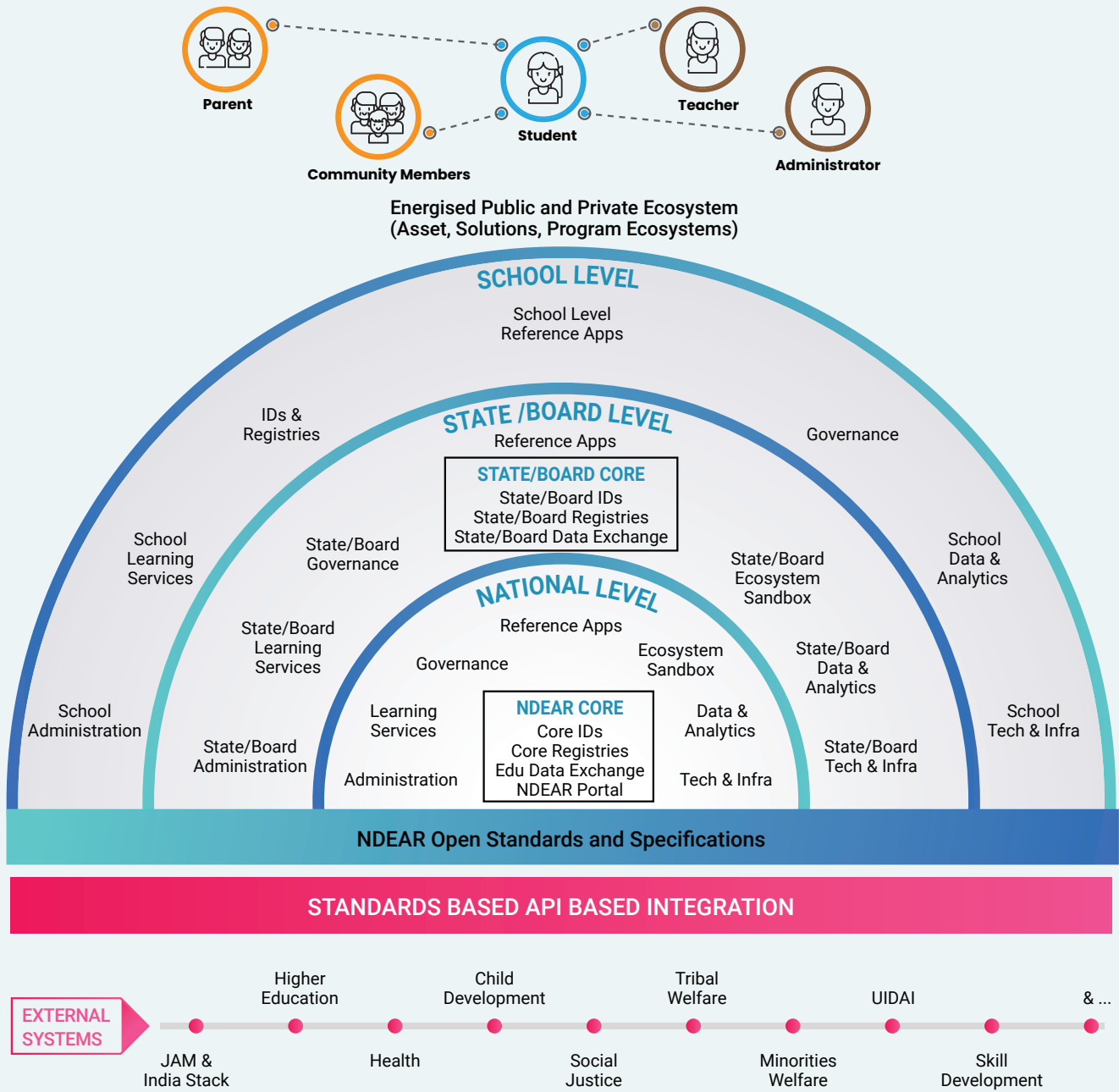


Figure 7 – Overview of Federated Architecture

As you can see in the above figure, NDEAR is not envisaged to be a set of central applications, rather a set of core building blocks along with few reference applications running in a federated manner across Centre, State/board, and school levels. Around the whole stack, across levels, are ecosystem partners who can use, contribute, and extend NDEAR services and applications to provide contextual learning environments to students and teachers.

2.4.2 Building Blocks - the essence of NDEAR

A building block is a package of self-contained functionalities defined to meet business needs through a set of services made available via APIs and optionally via reference solutions. Building blocks have to interoperate with other building blocks within the same system and across other systems. A good choice of building blocks will facilitate legacy system integration, improved interoperability, and flexibility in the creation of new systems and applications.

1. Characteristics of Building Blocks

In addition to adherence to technology architecture principles laid out earlier, each building block must have the following characteristics:

- Provide a standalone, useful, reusable, interoperable, and implementable set of services.
- Cross-functional across the value chain by design.
- Applicable to multiple use cases in the education domain.
- Ensure evolvability to ensure it is independently evolving.

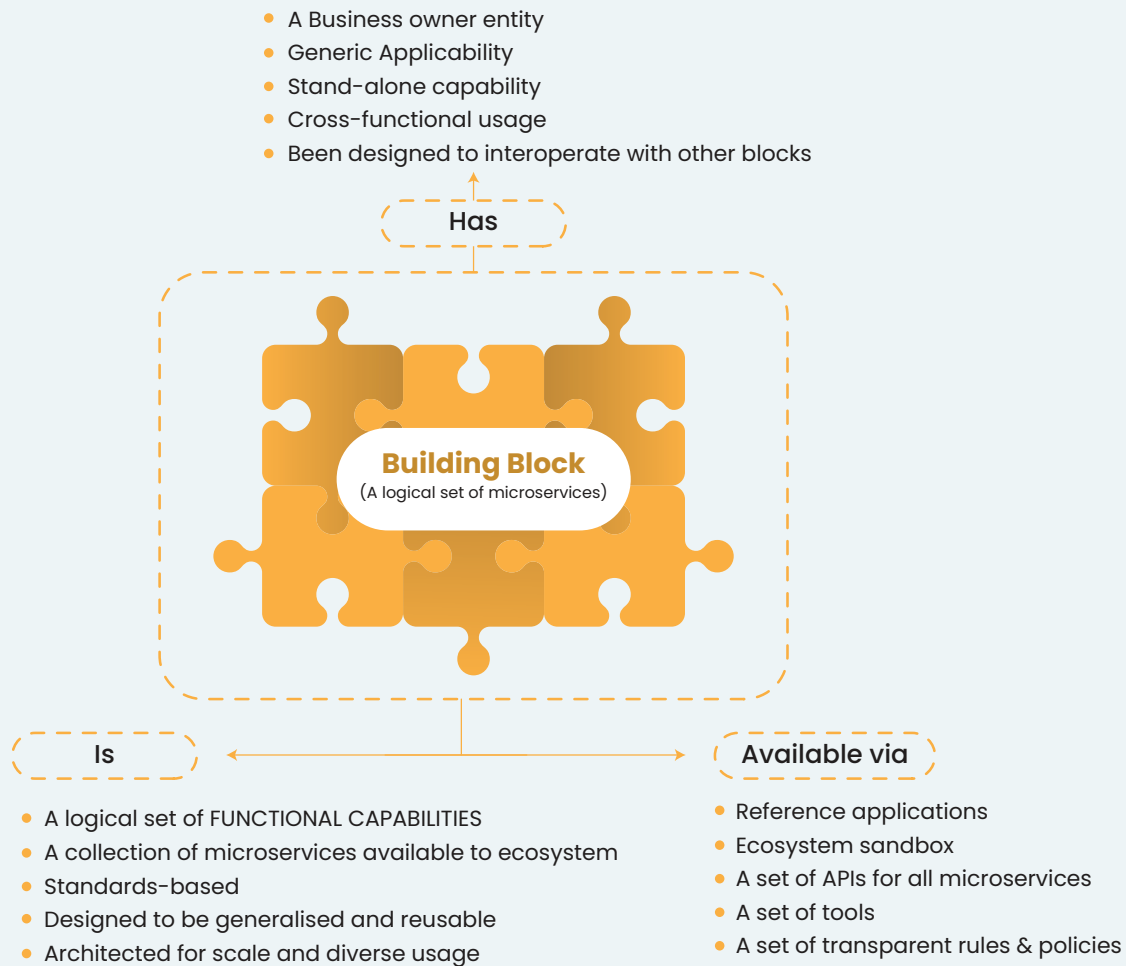


Figure 8: Characteristics of Building Blocks

Building blocks within India Stack are great examples of designing self-contained, reusable, services. All building blocks must adhere to the architecture principles laid out in this document. Typically each building block has two parts:

- A set of microservices powering the functionality, with well-documented open APIs for other systems to integrate.
- A set of interfaces (mobile, Web, SMS, etc) that allow users to interact.

Each building block within NDEAR must be owned by a national, State, or local institution, having clearly-defined roles for 'Business Ownership' and 'Technology Ownership'. While all minimum viable blocks are core to NDEAR, registries and master codes form the centre-piece for integration with all the other blocks and solutions. These federated registries allow master data and user/entity profile data to be maintained in an interoperable fashion with trustworthy attestations under user control. Identification of new blocks and adding new services within each block is an ongoing activity.

2.4.3 Building Blocks of NDEAR

Based on detailed studies of the existing education systems and discussions with stakeholders, 12 key building block categories consisting of 36 minimum viable Building Blocks have been identified within NDEAR across the 3 administrative levels.

NDEAR differentiates its building blocks into the following to help classify and develop them during its evolution:

- **CORE BUILDING BLOCKS:**

These constitute those building blocks that are necessarily built and managed as public goods and not given to the ecosystem to build. These are typically created and maintained at the National/State/Board Level (in a federated structure). These building blocks enable interoperability and act as glue between the rest of the building blocks and various solutions built on top. Core building blocks such as electronic registries, identities, etc also act as Single Source of Truth and/or System-of-Record (SoR). Core building blocks are offered as hosted services/applications at appropriate administrative levels. Core building blocks necessarily must adhere to the architectural principles of NDEAR to ensure interoperability and combinatorial solution building.

- **COMMON BUILDING BLOCKS:**

These constitute those building blocks that are built and offered as a choice to all of the NDEAR ecosystem. Like other building blocks, these may also be created and maintained either at the Centre or at State/board levels. Similar to core building blocks, common building blocks are also offered as a hosted services/application at the appropriate administrative level, except that these are offered as an option and the ecosystem may build alternative/enhanced versions of these to provide further choice. Like Core building blocks Common building blocks must also adhere to the architectural principles of NDEAR to ensure interoperability and solutioning.

- **REFERENCE BUILDING BLOCKS:**

These constitute those building blocks that are built and offered only as “source code/data” to enable various ecosystem players (be it Government entities or private) to rapidly build their services/applications. These are to be seen as “accelerators” and unlike Core and Common building blocks these are not offered as a hosted service/application. Through NDEAR Portal, these should be made available for download, use, enhancement, and customisation by ecosystem players. Ideally, the source code of most of the Common building blocks (since these are offered as a choice) should also be made available as a reference to enable others to rapidly build diverse applications on top of NDEAR. All reference building blocks should also be well architected and documented for better reuse.

All building blocks across Core, Common, and Reference should be organised well to allow easy discovery and reuse through machine readable catalogs, directories, and dictionaries within NDEAR Portal. At the time of developing various Building Blocks identified within NDEAR, it must be classified into any of the 3 (Core, Common, Reference) and organised. This report, per se, does not attempt to classify them upfront.

It is important to note that, as explained earlier, all services and reference solutions of NDEAR will be built and maintained across National, State/Board, and School levels. Also, many of the solutions beyond the Government-provided reference solutions/applications can be built by ecosystem players, thereby allowing many innovative choices for the institutions (boards, States, schools, programme partners, etc) and 5 key personas. Hence, it should neither be interpreted that all the building blocks would be built by a single institution nor maintained centrally nor be interpreted that Government will provide all the solutions/applications necessary for the education ecosystem as a whole. The capabilities listed in the diagram are only indicative and are expected to continually evolve. When building these blocks and reference applications/solutions, it is critical that they adhere to the architecture principles laid out in this document.

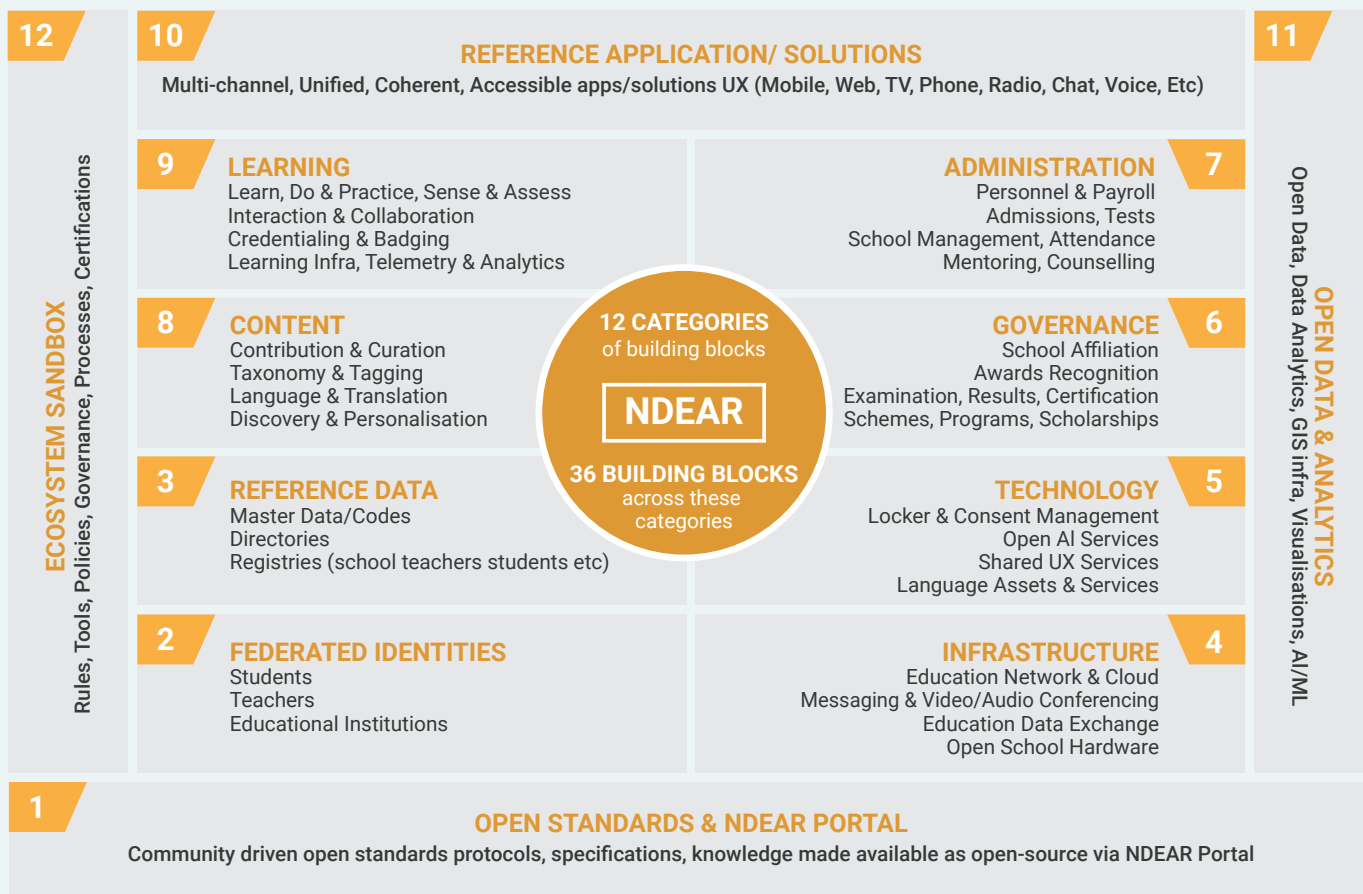


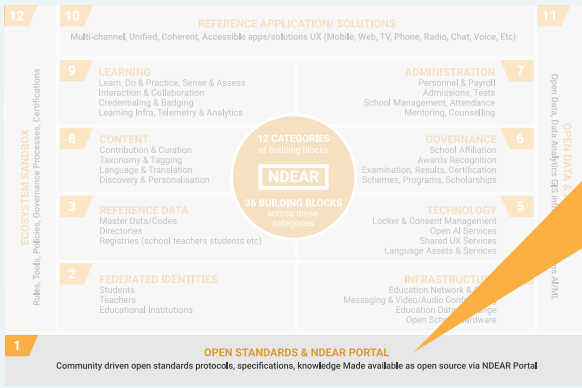
Figure 9: NDEAR Minimum Viable set of Building Blocks

As depicted in the figure above, NDEAR comprises 36 minimum viable building blocks across the following 12 categories:

1. Open Standards & NDEAR Portal
2. Federated Identities
3. Reference Data
4. Infrastructure
5. Technology
6. Governance
7. Administration
8. Content
9. Learning
10. Reference Solutions UX
11. Open Data & Analytics
12. Ecosystem Sandbox

The following sections explain these 12 building block categories and the Building Blocks within them in detail.

1. Open Standards and NDEAR Portal



BUILDING BLOCK CATEGORY

2

BUILDING BLOCKS

OPEN STANDARDS & NDEAR PORTAL

- OPEN STANDARDS:** Community driven open standards protocols, specifications
- NDEAR PORTAL:** A space where all NDEAR knowledge and assets are made as open-source to the community

a. Open Standards

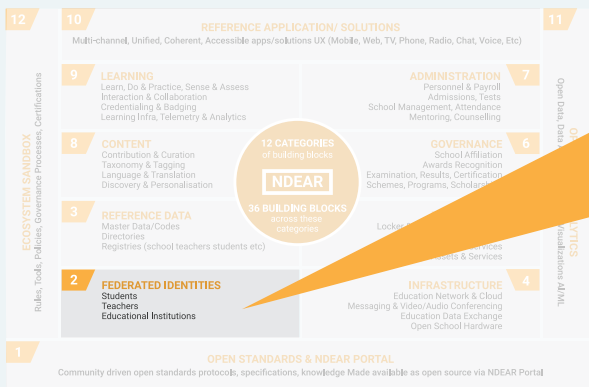
NDEAR being a federated architecture, various applications are expected to be deployed across Government, society, and market actors. Given this decentralised design, to ensure that these applications interoperate in a unified manner by providing a seamless experience to its users, it is necessary to define national-level open standards. This also ensures the portability of assets and data across States and applications. Defining national level standards is also critical for governance, strategic control, data security, privacy and overall compliance. Hence this is one of the key building blocks that cut across all building blocks of NDEAR and across all administrative levels.

Later in this section, the standards and recommended specifications are provided in detail. Note that these are evolving in nature and hence this list should not be construed as the only and final list. With time, these standards need to be updated, new ones introduced, and old ones retired.

b. NDEAR Portal

Considering NDEAR is an evolving, ecosystem enabling architecture, it is essential that all the architecture artifacts, documents, standards, governance, directories (of building blocks and compliant applications), collaboration, etc. are managed through a single public facing website. This is the sole purpose of the NDEAR Portal. Bringing the NDEAR artifacts and governance through the common portal allows it to be a living and ever evolving architecture, with strong collaboration with the ecosystem. The institution who is the custodian of NDEAR will be in charge of this portal.

2. Federated Identities



BUILDING BLOCK CATEGORY

3

BUILDING BLOCKS

FEDERATED IDENTITIES

- Students
- Teachers
- Educational Institutions

This category provides the fundamental building blocks that manage the key entities and their identities required for any ecosystem transaction/ interaction.

Digital identity, of people, things, and entities, plays an important part in building interoperable and portable assets and experiences for users. Given the decentralised architecture of NDEAR, it is essential to understand that even the IDs will be defined, managed, and captured in a decentralised manner.

The essence of an ID is to provide unified control to the subject represented by the ID (or owner of the subject represents a “thing” such as devices). The ID enables the subject to be able to obtain, manage, control attributes, receive attestations, manage profile and transaction data attached to that ID, consent to one’s own profile and/or data, if required revoke, and manage the lifecycle.

A digital identity system typically provides the following core capabilities:

- i. **Management:** creation, updates, lifecycle management, and protection of the ID.
- ii. **Authentication:** verifying ID claim by the requesting party of the ID holder using one or more factors (Password, OTP, biometrics, etc).
- iii. **Attestations:** receive, attach, consent, share attestations that are stored against specific attribute/ attribute-set in the ID (e.g. if ID profile has an address, ability to have a digital proof of address or if ID has an academic qualification, the ability to have digital proof of the qualification, etc.)

Given India’s large diversity and education levels, it is essential that the architecture of Government systems be that of supporting diversity and be most inclusive. While the intent of the State is to care for the vulnerable and poor, systems must still be designed to provide agency and choice to people.

Understanding Uniqueness

The uniqueness of ID is an important subject to explore. It is essential to understand if the “uniqueness” is from the ID owner perspective or from the perspective of the State. These two are fundamentally different and both are necessary for different purposes. State enforcing uniqueness must be used sparingly and only when it is absolutely necessary. The Supreme Court of India clearly articulated the need to have privacy as a fundamental right, while allowing Government systems to enforce the uniqueness of ID for specific usage, where it is appropriate and necessary.

NDEAR and Identities

Under the NDEAR federated architecture, ID should be kept as local to the context of the ID owner instead of all being held centrally. Each ID record should be owned and controlled by the owner of the ID record. All these IDs are just locally unique within the ID registry and not nationally unique unless explicitly needed (e.g. school ID). Since these will be within the registry, ID context will be of that registry and reference will be made to the ID using the registry URL.

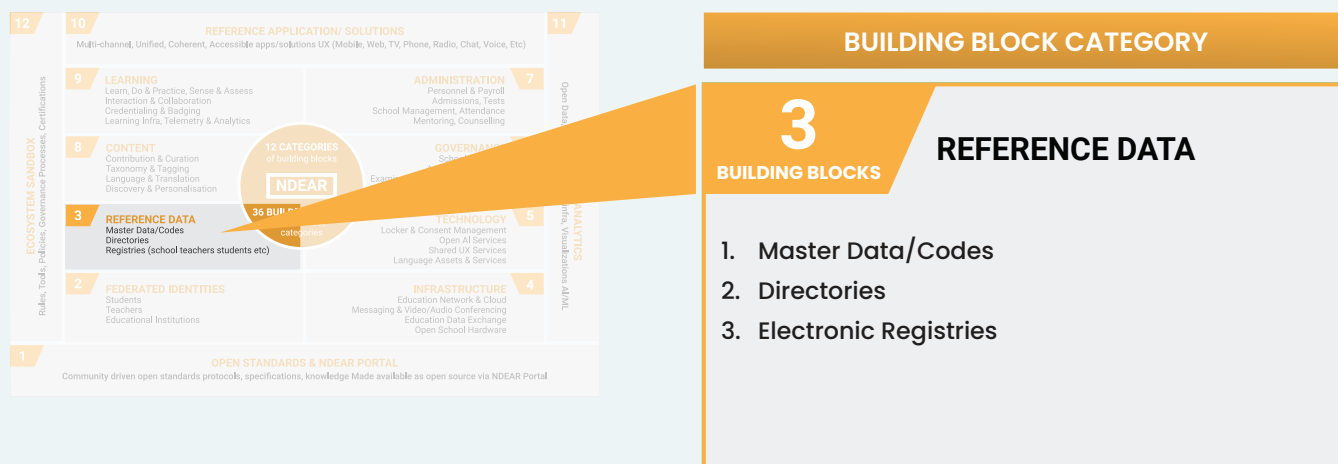
Depending on the sensitivity of the data, access to the ID and profile registry may be of 3 types:

- 1. Fully protected:** all records and attributes of the records accessible only via consent (e.g. student/ teacher records).
- 2. Partially public:** some attributes are public while others are protected via consent (e.g. school registry where several attributes of schools such as name, location, etc are public while contact details of the person in charge may only be available with consent).
- 3. Fully public:** all attributes and records of the registry with IDs are available as public data (e.g. geographic data records with IDs).

NDEAR ID architecture shall be federated, privacy protected, and designed to work seamlessly with consent manager and virtual IDs as per the upcoming Personal Data Protection Bill in India. The recently released discussion paper on DEPA (Data Empowerment and Protection Architecture (DEPA) by NITI Aayog spells out consent manager and federated virtual ID architecture where the user is in control of ID, consents, and their data. NDEAR ID and data architecture shall be in alignment with this architecture.

Operationalisation of IDs needs to be planned through a set of guidelines, especially those relating to the minimal data elements, the format of the ID, if any, the process to make it portable, obligations of the institution/ ID Provider, etc. This is beyond the scope of this document.

3. Registries and Reference Data



a. Master Data/Codes

Master codes are pre-assigned codes to data elements, so that the data entered into a system can be reliably read, sorted, indexed, retrieved, communicated and shared between systems. Indicative list of data elements for which master codes shall be required are as follows:

- Marksheet, Award types
- School Category
- Stream
- Managing Body type
- Subjects
- Social Categories
- Benefits types/categories
- Languages
- Location (Local Government Directory or LGD)
- Other Category codes

These master codes must be maintained in a single source at an appropriate level (national or State) in digital form (machine-readable) and made available via APIs for other blocks and applications to use.

b. Directories

Directories are a public listing of various master data and codes in machine representable and API accessible way. These are simpler versions of electronic registries and only list fully public data. Since data listed in directories have no link to any person, entity, or things (controlled in person/entity), directories are considered part of open data (master data) and do not require any consent mechanisms and access restrictions.

c. Electronic Registries

In the education domain, it is essential that data about schools, teachers, students, administrative officials, subjects, textbooks, etc. are maintained through a set of federated 4th generation registries (not kept central, but kept within various State/ Centre/ department systems which are the primary keeper of that data). These registries must be designed to be easily accessible by other building blocks and usable through “registry-as-a-service with open APIs” beyond the traditional portals for end users to view and access. School, teacher, and student are core registries envisaged in NDEAR (across federated levels and not as a central database), not to mention other registries such as asset registries, device registries, etc.

While all State and Central governments have the need to maintain master data within the education domain, few have managed to successfully collect and keep it up to date. Almost no system today has exposed reusable registries for others to build on. Many States today have such master data scattered across paper lists, databases, and spreadsheets.

Below are a few key registries that are enabled within NDEAR.

School Registry

Currently, each school is uniquely identified by a Unified District Information on School Education (UDISE) code. In addition to these, there are multiple schools / institutions which are not onboarded on UDISE+ or may be using their own codes for institutes. There is a need for a master registry to facilitate institution controlled CRUD (Create, Read, Update, Delete) operations while keeping attestations/approvals to appropriate authorities and act as a single source of truth for all other building blocks and systems. UDISE code has been recognised for the purpose of uniquely identifying schools, pre-schools, vocational training institutes and other institutions pertaining to school education. UDISE+ shall be augmented with the features required to perform School Registry with open APIs.

Teacher Registry

Similarly, teachers have multiple entry and exit points in the education system and shall require the teacher registry to be maintained at the Central level or at the State level with national access (with necessary access control and consent flows). Student and Teacher Directory may leverage Aadhaar, PAN or other existing identifiers for unique identification as necessary.

Student Registry

It is important to standardise how students are identified at any point. For the entire lifecycle, a student has multiple entry and exit points into and from the education system. Different IDs are allotted which are only relevant within the scope of a limited digital environment and thus calls for a unified, but decentralised registry for students. It will be used to help students, parents, and teachers map and facilitate the entire journey of a student spanning across different stages of scholarly life including childhood care, school education, distance learning, up-skilling and vocational training. This ensures that the education records created for a student can be issued to the correct individual, in the control of the student/ parent, and can be shared/ used using consented access. By providing control of the record back to the student/ parent, the record and contact information can be kept updated by the student/ parent.

Other Registries

Apart from student and teacher registries, other key directories in an educational ecosystem are mentioned below:

- Education Boards
- Examination Boards
- Education Research & Training Institution
- Management Bodies
- Philanthropy /NGOs
- Counsellors etc.

Annexure 3 provides more details on electronic registries, its evolution, and core principles. The following diagram shows the interconnection between IDs, Master Codes, and Registries.

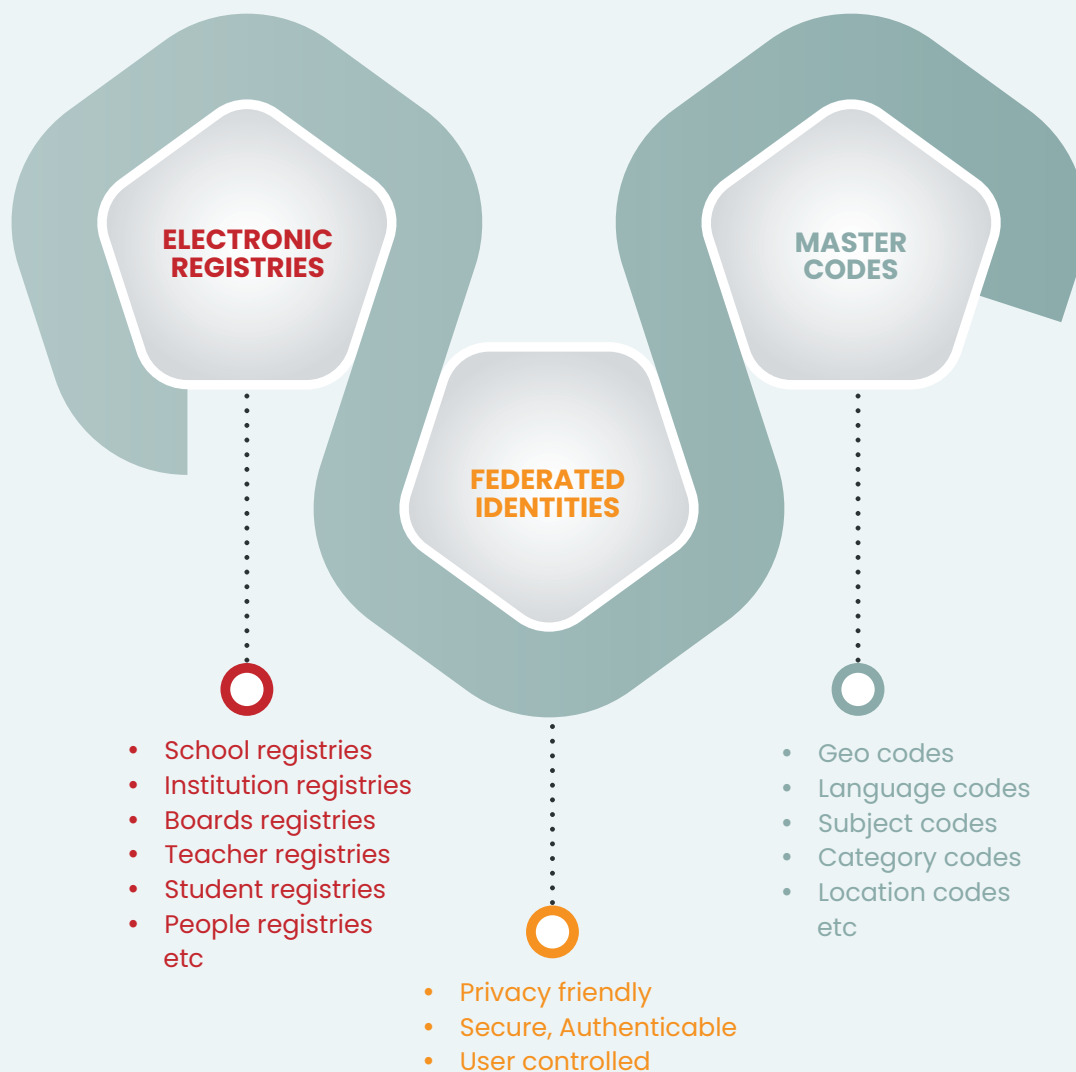
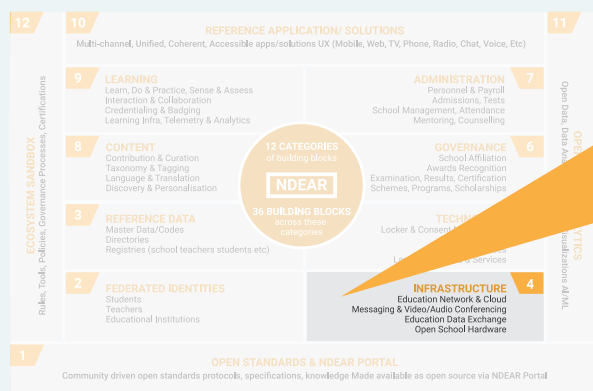


Figure 10: Federated IDs, Registries and Master Codes

4. Infrastructure



BUILDING BLOCK CATEGORY	
4	INFRASTRUCTURE
BUILDING BLOCKS	
	<ol style="list-style-type: none"> 1. Education Network & Cloud 2. Messaging & Video/Audio Conferencing 3. Education Data Exchange 4. Open School Hardware

a. Education Network & Cloud Services

Privacy by design being a key principle of the NDEAR, an infrastructure layer needs to be established for the management of the key data services in a compliant manner. The objective of this building block is to ensure that education data and its transfer/ movement is always secure and adheres to all privacy requirements.

Secure Education Networks

Entities running NDEAR compliant services should be built to work on public networks by default with open security standards. Wherever access to sensitive or aggregated data is involved, additional layers of security such as VPN or MPLS etc. may be explored.

Education Cloud

Entities running NDEAR compliant services should look to build or leverage cloud infrastructure built on the MeitY initiative of Government Community Cloud (GCC) with stronger security and privacy policies.

Security and Network Operation Centre

To ensure 24x7 availability and security, entities running NDEAR compliant services should build Security Operations Centre (SoC) and Network Operations Center (NoC) as necessary or leverage existing operations infrastructure. Given the federated nature of NDEAR, these centres may be at National or State or department/school levels, as appropriate.

b. Messaging Services

SMS/Email/IVR/IM

These services provide generic APIs for integrating messaging platforms like email, SMS, Instant Messaging and IVRs etc. along with bridges to popular commercial chat and messaging platforms. This allows other blocks of NDEAR or solutions built on top of NDEAR to leverage these APIs.

Video/Audio Conferencing

Various interactions within the education domain, across both learning and administration blocks, require a mechanism for users to conduct “synchronous” sessions using video/ audio conferencing technologies. NDEAR technology block could provide a default video/audio conferencing capability as a set of APIs that can be embedded within application services in other building blocks. While NDEAR may provide a reference solution for video/audio, NDEAR applications should be designed to provide a “choice” to users by offering standard pluggable integrations with other video/audio solutions as well.

c. Education Data Exchange

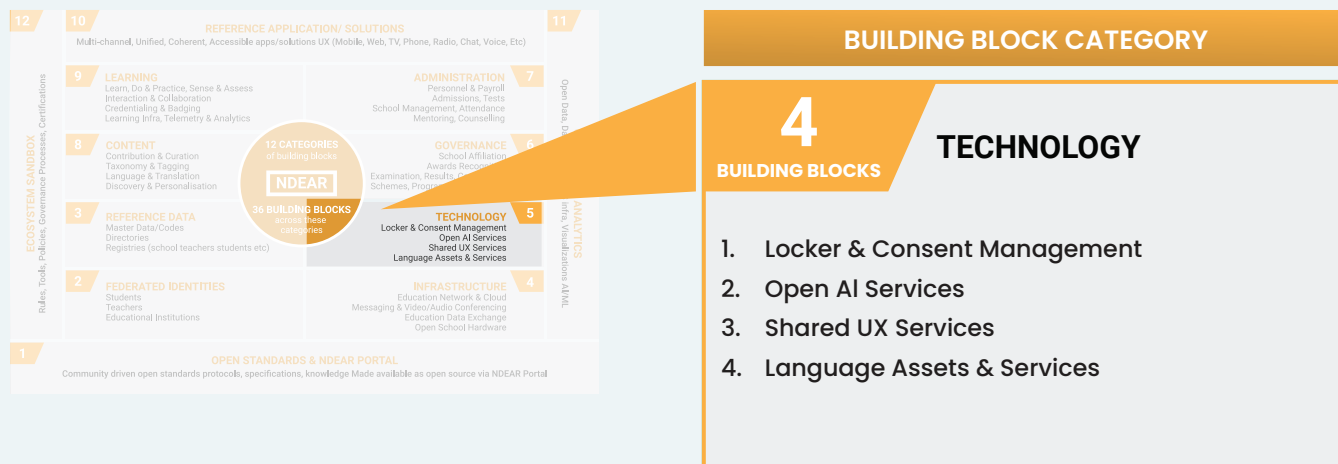
A common data exchange platform may be made available for various NDEAR building blocks and systems to interchange their data in a secure and, if the data involves sensitive personal data, in a privacy protecting manner. Such an exchange platform does not store the data, rather, allows end-to-end secure exchange of data in an interoperable manner. It is not necessary that a central exchange be used for exchanging data among systems, rather, this is an optional service that can be leveraged by entities building NDEAR building blocks and solutions.

d. Open School Hardware

To ensure access to digital education across the country, it is essential that a set of open hardware components are encouraged by the ecosystem to be plugged into NDEAR to consume content and enable learning interactions within a school, labs, and classrooms. Hardware components could include, but not limited to, smart boards, local Content Delivery Network servers (CDN servers), open WiFi hubs compliant to PM WANI, etc. Building hardware that can be used seamlessly with NDEAR services requires standards,

ecosystem and reference hardware solutions. The institution anchoring NDEAR may work with MeitY, States, and the education ecosystem to come up with open specifications (as part of “standards” building block) and incubate an ecosystem to provide the solutions, field support, etc.

5. Technology



This block provides various shared technology services that can be used across all other blocks to enable reuse, scale, security, and avoidance of duplicated efforts. In addition to the core architecture principles of all services, characteristics of services in this block are:

- **Generalised:** Services in this block are atomic, minimal, and most importantly generic in nature. This generalisation is very critical to ensure all services from this block can be used by services from other blocks in a wide array of contexts to meet diverse use cases.
- **Non-functional:** Services within this block are necessarily non-functional and technological in nature. All functional services are abstracted into other blocks whether it be registry functions, learning functions, or administrative functions. Services within this block are reusable non-functional services that are generalised, abstracted, and made available as APIs.
- **API-driven:** Since services in this block are consumed by/ within services of other functional blocks, it is essential that these services are built using a set of open APIs with well-defined and documented input schema, output schema, version control, and a set of automated test cases that act as the “promise of the interface contract” along with backward compatibility policy.
- **Accessible:** Services within this block shall provide technology support for designing the user experience for atypical/ differently-abled persons and those with special needs. With the predicted growth of digital presence in the education sector, this is essential for ensuring universal inclusion.

The following sections describe many of these Technology services in brief. Note that this list of services is evolving and not complete, by design.

a. Locker & Consent Management

Education Locker / Depository

The Education Locker is a standards-based interoperability specification that can be implemented by multiple players to enable the creation of an Education Record ecosystem. Locker/ Depository shall leverage the digi locker/ National Academic Depository.

Consent Manager

Education records are personal for an individual and every access to each record requires the explicit consent of the individual. The electronic consent framework specifications notified by MeitY and *National Data Sharing Policy*⁸ should be used to develop the information sharing processes within the framework. The consent Manager shall take care of granular/ parental consent as per Personal Data Protection (PDP) Bill and be compliant with legal requirements and best practices in dealing in personal data.

b. Open AI Services

Leveraging AI/ML technologies is critical to empower users and provide access to knowledge and learning experiences. A set of reusable AI services, open-source libraries, open-source models and data sets could be built for the education domain that can be leveraged and embedded within other building blocks. While AI is leveraged, it should be built to amplify human actors, eliminate biases, and should assist in effective teaching / learning and management rather than seeing it as a full replacement for humans. Content translation in regional language, speech recognition, personalisation, etc. is a critical part of this.

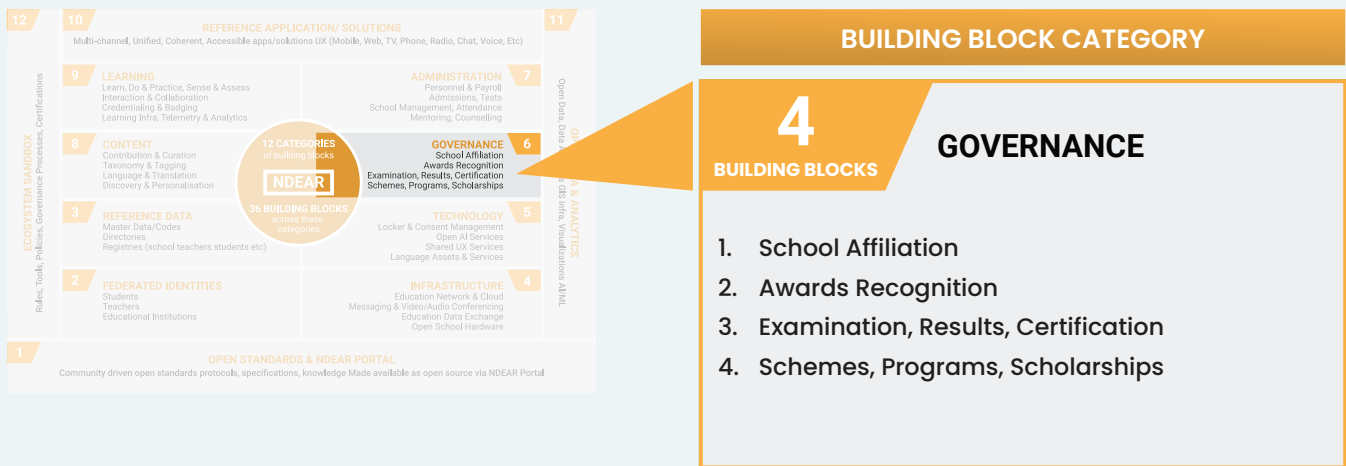
c. Shared UX Services

Similarly, new user experience technologies such as “conversation engines” (eg. chatbots), “AR/ VR/ 3D/ Gamification”, maker experiences such as robotics, IoT devices, etc. should be explored as reusable core services that can be used across various functional blocks.

d. Language Assets & Services

Considering India’s language diversity and richness, NDEAR should look to create common language assets e.g., wordnets and technologies to help with learning, knowledge organisation, translation, speech, and other aspects. Many Indian open-source projects already exist that can be leveraged to bring these together for comprehensive generic “bhasha” APIs. Assets built within various Government and research institutions must be leveraged by upgrading and integrating them as reusable open-source assets or services to amplify and extend the work.

6. Governance



⁸<http://dla.gov.in/sites/default/files/pdf/MeitY-Consent-Tech-Framework%20v1.1.pdf>

a. School Affiliation Services

These services address school affiliations, approvals, audits, inspections, recognition, school score cards, monitoring, and other feedback/grievances. These services can be used by States and by School Boards to manage the affiliation of schools under them. These transaction services will fully leverage the school registry and unified profile.

b. Awards & Recognition Services

These services address the workflows, rules, and transaction capabilities for Centre, States, Boards, and ecosystem partners (an NGO could also use award services, if they wish to) and schools to issue awards, recognition etc. for teachers, students, and other users. Awards can be issued in digital format via digilocker and also printable format. These services shall allow the creation and lifecycle management of awards and recognitions. These services shall leverage registry services and infrastructure services (such as SMS/ Email, etc). Reference applications (portal/app) would interface with these services out of the box while still exposing these services as independently usable APIs.

c. Examination, Result, Certificate Services

Formal testing/examination is an integral part of education to ensure that learners are acquiring the knowledge as per expected learning outcomes. Results / Certificates are recognition provided by the schools / institutes to the students after successful completion of undertaken learning through the assessment process. Results portal is a great example of a gateway to exam results in India. NDEAR shall support multiple types of assessments as part of learning services as per the varied needs of learners and courses offered. Federated depositories shall be created for online storage and sharing of awards details online with external parties with consent. National Academic Depository / Digi locker shall be leveraged for award depository. All awards and certificates will be issued as machine-readable, verifiable documents, with a print option, as per common schema standards.

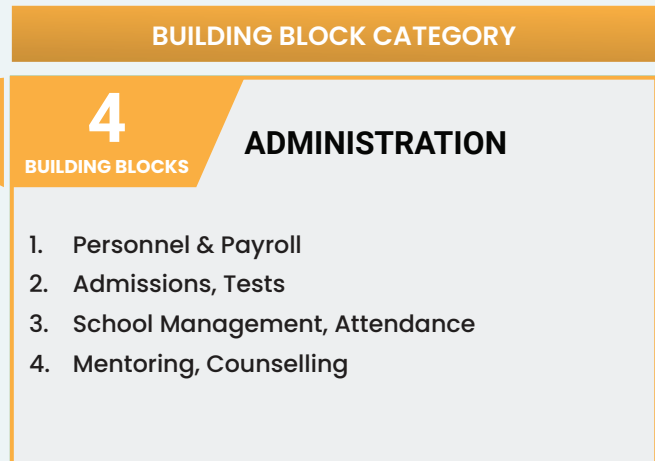
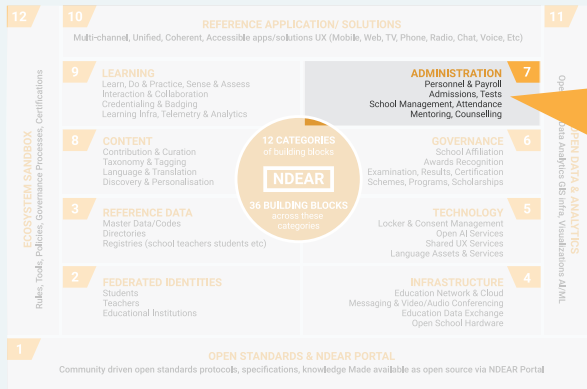
d. Schemes, Programs, Scholarships

Government, as well as non-government, bodies provide multiple welfare programmes / schemes for weaker sections of the society. These programmes / schemes are owned by Central, State or jointly by both. NDEAR shall support the implementation and monitoring of schemes by government or non-government bodies. Some of the schemes are Samagra Shiksha, Mid Day Meal, Padma Likhna Abhiyan, National Means-cum-merit Scholarship Scheme, National Scheme for incentives to Girls for Secondary Education, and National Awards to teachers. Scheme management services shall address scheme planning, definition, rollout, funds disbursed, monitoring, auditing, and so on and shall be integrated with registries. Scheme management allows the Government to ensure unification across schemes, easier enrollment for beneficiaries, and efficient fund management.

Scholarship Services

Scholarship services address the workflows, rules, and transaction capabilities for Centre, States, Boards, and ecosystem partners (a company could also provide scholarship via CSR if they wish to) to provide scholarships for teachers and students. Scholarships can be given based on academic performance or other rules and can leverage the Aadhaar-enabled direct benefit transfer (DBT) model to directly deposit in a bank account. These services shall leverage registry services and infra services (such as SMS/ Email, etc). Scholarship services are already available through a national scholarship portal (as a reference application) catering to the entire nation.

7. Administration



Administration services building blocks help in providing education efficiently to the child and goes beyond imparting knowledge and ensures that the daily needs of students/ teachers are fulfilled, and they can focus on learning and teaching.

When built, these services shall be made reusable with open APIs and as open-source code, so that many applications can reuse these services as-is or embed these capabilities within those applications, be at Centre or State or school levels. These can be then offered either as API services, open-source components, and also via a set of reference applications for States to use.

The following list is merely indicative and many more services towards management of CSR, management of school facilities (sports, library, labs, playground, etc.), services that enable and support extra-curricular activities, etc can all be subsequently added.

a. Personnel & Payroll

These services address various aspects of personnel management, payroll, appointment, transfers, pension, service books/records management, manage payments, etc. These services will leverage teacher and other personnel registries to use the unified personnel profile ID within the registry to attach various workflows and transactions.

b. School Management, Attendance

These services are meant to be used for building school management solutions. These include admissions, attendance, feedback, event management, community engagement, virtual PTA meetings, etc. All these services and reference UX shall be made available as open-source (so that affordable private schools can leverage as well) and also as hosted environments (for Government schools). These services will be integrated with registry services, shared infra services, and other building blocks.

Civil Works, Projects

These services allow states and schools to manage civil projects end-to-end for school facility improvement programmes. Services shall include most of the typical project management capabilities such as budget management, personnel assignment, task management, calendaring, tracking, auditing, and so on. Reference application block shall also have out of the box reference app/portal for using these capabilities.

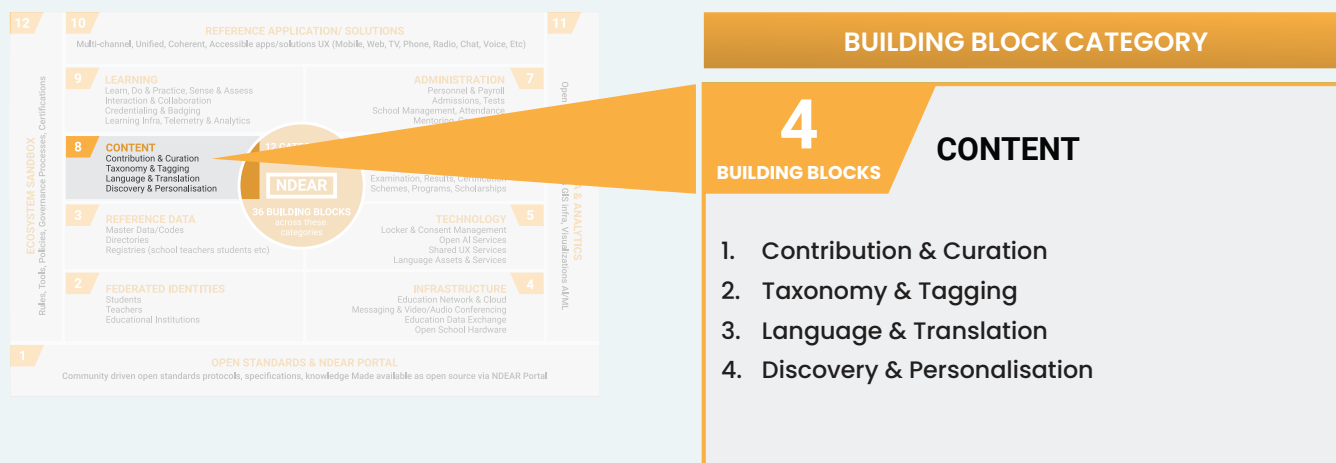
Finance & Accounts

Finance and account management are key services to manage budgets, allocation, accounting, and related aspects for both at State and school levels. Administration building block shall contain these services provided for the Governments. As per NDEAR principles, open sourcing these modules allow even affordable private schools and communities to leverage these, enabling faster digitisation of accounts and financial aspects of the entire ecosystem.

c. Mentoring, Counseling

One of the core services children need is access to various counselling services in various matters such as study, career, physical & emotional, exams, admissions, etc. While high end schools and children coming from privileged backgrounds do have access to these, a large population of students do not have access to any form of formal counselling. It is important that these services are made available across the country in various languages. These digital services shall use open protocols to bring the entire ecosystem of counsellors onto a common infrastructure through registries, attestations, feedback, etc. so that students get access to virtual counselling services (both anonymous and identified). These services should be embeddable into school management systems and also available as standalone for consumption in various contexts.

8. Content



Content services are at the heart of this building block. An entire set of content services shall provide a mechanism for all key personas to engage in learning and teaching interactions through a series of coherent, integrated, guided journeys. These services shall be enabled to ensure that core NDEAR principles such as “enabling diversity”, “enabling access”, “enabling ecosystem”, etc. are fully adhered to. Digital infrastructure shall provide agency to institutions and users in terms of building appropriate content, supporting different taxonomies, and creating contextual solutions and fully support seamless interplay between physical-digital mediums, synchronous-asynchronous modes, diverse device types, and self-assisted interactions. DIKSHA content services are currently the best example of this and are used by millions of users daily across the nation. More details on content services are available in Annexure 3.

a. Contribution & Curation

These services allow curriculum-linked content sourcing and curation, be it for linking to energised textbooks, online courses, quizzes, or any content for that matter. Contribution service supports multiple models for content sourcing – sourcing from a pre-selected set of individuals or organisations, crowdsourcing contributions from masses – both organisations and individuals, and re-using digital content already published. The Centre, States and education Boards can leverage content sourcing tools to engage the ecosystem of their teachers, different government institutes, community of organisations and individuals at large. When seeking contributions, additional capabilities to go through a nomination process can also be enabled.

Apart from content sourcing tools, content authoring tools shall also be available allowing teachers or users, designated by centre or state departments, to create interactive digital content. Content curation services can be used by sourcing organisations to ensure that only good quality content is eventually published to users.

Once the sourced or created content is ready, it needs to be checked for content guidelines of the sourcing organisation (note that while common guidelines may exist, the federated nature of the architecture allows various administrative organisations at various levels to have their own rules to meet their context). Once the quality check is done, it needs to be tagged, organised by attaching to one or more categories, pedagogic correctness verified, and eventually published. Curation services shall provide a wide variety of tools (both automated as well as manual) and workflows to content sourcing organisations to manage this process.

b. Taxonomy & Tagging

Framework service (for mapping various taxonomies and curriculum frameworks) allows various boards to create one or more of their own curriculum frameworks linked to classroom learning or teacher professional development. Taxonomies may include grades K-12 school education, early learning, foundational learning, inclusive education, teacher training and several others. Defining various taxonomies as machine represented semantic structure helps with organisation and categorisation of content and serves for easy discovery of content by users. This also allows efficient tagging of each content on the platform to relevant grade, medium, topic, learning outcomes or learning objectives. Frameworks are crucial, for e.g. for content to be tagged to energised textbooks, during course creation, among other uses. Efficient framework infrastructure enables personalised learning by leveraging artificial intelligence and machine learning algorithms. Learning analytics of achievement (by learning outcome or learning objectives) is enabled through framework service of the learning building block. An open taxonomy infrastructure for organising knowledge across multiple learning frameworks is extensively implemented within DIKSHA. More information on taxonomies can be found in Annexure 3.

c. Language & Translation

Education infrastructure will not be complete if the core building blocks and services do not address the language diversity of India. NDEAR shall give special focus to address these through technologies to enable dictionary/wordnet services, input capture services, speech detection and analysis services for children learning language, translation services specialised for learning content, text digitisation services (such as optical character recognition or OCR) for capturing assessment data, etc. With the advancement in AI/ML and wide access to mobile devices (with camera and microphone), time is ripe to ensure these technologies are leveraged to enable millions of users to interact, discover, learn, and collaborate in Indian languages.

d. Discovery & Personalisation

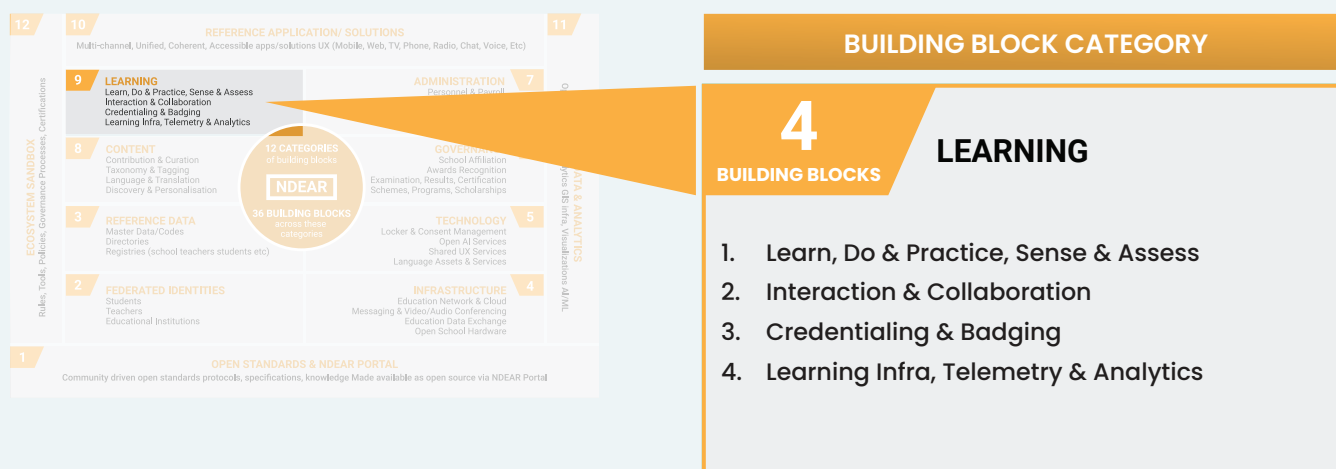
For large scale adoption and usage, it is critical to ensure users across all personas can efficiently discover, share, and consume content that is most relevant to them when needed in their learning context. While “search paradigm” is popular, at scale, most users find it hard to discover relevant content for them. This is due to various factors such as complexity of search semantics, language and vocabulary differences, lack of context when doing general searches, lack of capable adults supporting discovery, and so on.

Hence discovery services shall provide multitude of unbundled capabilities such as using QR codes, chatbots using conversational techniques, metadata-based advanced searches, easy sharing of content and collections by users, multi-lingual mappings, advanced tagging to do push targeting, etc. Discovery services shall offer advanced search and discovery capabilities using the terms in the taxonomy, their equivalent terms or adjacent/related terms. For example, a teacher searching for “Single Digit Addition” may also discover content related to “Double Digit Addition” and “Carry Over” because these are related terms.

Personalisation is an advanced gradient of discovery where the system automatically learns user behaviour, tries to get the right context, and then creates recommendations and “directed journeys” for the user by leveraging content and taxonomy services. It is pertinent to remember that NDEAR needs to address all key personas and hence these services should not only focus on students; it should also be built as generalised services for personalisation for teachers, parents, administrators across consumption, creation, and management interactions. Personalisation also should not be misconstrued as a mechanism for replacing teachers and mentors; it is merely an aid in easing discovery and navigation. Personalisation can be done at a cohort level allowing the system to gradually move from most generic to cohort based to most individualised in an evolving manner.

To implement the above capabilities, it is critical that content repository and searches are seen not as simple database and text indexing issues, rather as a careful architecting of “semantic knowledge structure” mapping, layered with multi-dimensional discovery services and then building advanced telemetry-based cohort or individual personalisation capabilities, all as unbundled and reusable services within NDEAR.

9. Learning



Learning services building block shall provide unlimited access to robust and comprehensive learning experiences and associated services to all the actors. The DIKSHA platform, with microservices, is a great example of this block. As part of the harmonisation of various learning platforms, they can be upgraded or consolidated by MoE to leverage and unify.

This building block is one of the most critical blocks to enable a wide variety of services spanning from learning, assessments, tracking learning outcomes to interactions and credentialing. In addition to these services already available on DIKSHA, reference applications such as the DIKSHA portal/mobile app and SWAYAM are offered to make the learning experience easily accessible to the entire nation. These learning experiences are not limited to students, rather, these services shall be used for learning of students, teachers, administrators, and anyone who wants to learn (including children who have dropped out, not in school, learners with special needs, etc).

a. Learn, Do and Practice, Sense and Assess

Assessment has always played an important role in education. Most, if not all, types of formal education use some sort of assessment, typically including a final exam to earn a grade, a degree, a license, or some other form of qualification. Today, assessment is no longer restricted to grading at the end of an instruction (summative assessment). Its value for continuous monitoring & feedback (formative assessment) and guiding of the learning progress (means to learn), without being necessarily used for grading purposes is recognised. Formative assessment, including self-assessment, can play a vital role in motivating learners since it provides them a way to judge their own competency level and allows them to track their progress.

Answering questions and solving problems is an effective way to learn. If the questions focus on micro-concept level assessment of student's proficiency, it is possible to identify strengths, areas that need focus and improvement, and recommend the relevant content to the student that specifically addresses the individual learning needs. Questions that are tagged with appropriate pedagogic metadata and associated with relevant concepts will enable "questioning" to be used as an effective means to encourage learning. Combining these capabilities with the "standardised learning outcome" taxonomy allows continuous sensing of learning levels across the nation.

b. Interaction & Collaboration

Active communication and collaboration between practitioners are known to lead to significant improvement in learning outcomes. In the offline world, such shared learning requires the facilitation of meetings, workshops and conferences and necessitates physical affinity. This requirement puts a burden in terms of scheduling, logistics and cost of operations.

A digital infrastructure provides unparalleled opportunities for extensive collaboration without requiring users to be physically together, extensive scheduling, and logistics. A well designed digital infrastructure can significantly reduce the cost of collaboration while dramatically increasing access to expertise and mentorship. In addition, collaboration on a digital platform allows for the participation of diverse groups across geographies and enables sharing of best practices, discussion on key topics, celebration of successes, etc. Imagine the possibility of a student in Kerala learning Hindi from a master teacher from UP or getting the best mentorship and guidance from experts sitting far away using a smartphone and Internet connection.

This interaction and collaboration with teachers, mentors, experts, and peers are what these services are built to address. These generalised interactions and collaboration capabilities are unbundled and can be made available as microservices for reference applications and ecosystem applications to use. These interactions can be either synchronous (when users are virtually together at the same time, audio/video conferencing, phone call, etc are examples of these) or asynchronous (when users can interact with each other without being virtually available at the same time, chat, discussion boards, etc are examples of these). It is also important to ensure these services are not specifically built only for one persona, rather built in a manner which can be used across student-teacher, student-student, teacher-teacher, teacher-parent, and other interactions.

Also, it is necessary that these services are not thought of as a standalone feature (such as video conferencing portal or independent discussion boards). Instead, they should be thought of as microservices and components that can be embedded into the actual transaction context. Learning interaction and collaborations services focus primarily on bringing collaboration into the learning context.

c. Credentialing & Badging

Learning is a continuum of micro-loops of "Ask, Act, Assess" cycles. Asking to understand and learn; Acting to practice and implement; and Assessing to validate if the Ask-Act steps indeed resulted in the desired outcome. Every significant action results in a "proof of that action" which can be issued to the actor as a "credential" that is verifiable and portable. This design of NDEAR allows unbundling of learning itself into micro-steps resulting in a series of micro-credentials that are attested by various systems/people allowing learners to carry those proofs (of actions and assessments) from one context to another (one school to another, one application to another, school to jobs, etc). Badging is a simpler form of credentialing typically used to indicate higher trust levels for people/ things/ entities. For example, a content could be badged as "NCERT Approved" (an entity attesting the content and issuing a badge) or "Most Popular" (a system deriving popularity score and auto-issuing a badge).

Thus, it is essential to have core credentialing and badging capabilities to be built as "generalised", "templatised", "rule/ rubric-based", "event-based triggerable" services that can be embedded and consumed by various application layers across the NDEAR ecosystem. NDEAR proposes to make all credentials (certificates, awards, badges, etc.) natively digital, machine readable, verifiable, and universal

across various public and private educational issuers/systems.

A “lifelong learning passbook” (electronic Personal Learning Record – ePLR) shall be created that constantly accumulates all competency proofs based on micro/ macro-assessments as well as other credentials (proof of internships, proof of projects, etc.) in machine readable formats. This is then given in the control of the learner (or parents in the case of minors) as part of data empowerment using DEPA architecture.

Annexure 3 provides credential structure and core principles in detail.

d. Learning Infra, Telemetry & Data Analytics

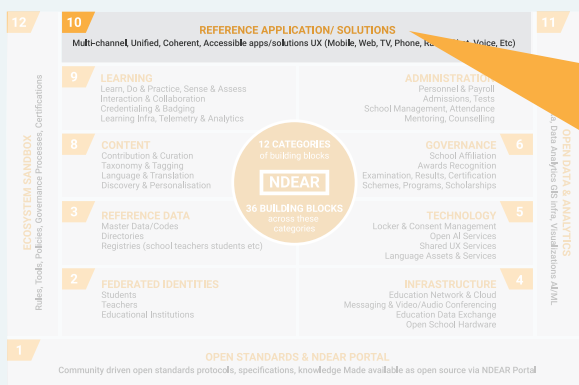
Learning infra services provide shared services within this building block that are leveraged across all learning services. These include data pipelines, graph based knowledge engines, virtual ID services, semantic indexing services, event services, versioning services, etc. These are horizontal lower level technology services that are shared across all learner services, built using open-source, and provided as APIs within this building block.

The philosophy of micro-functional services extends to data architecture, tracking micro-level events and data products that enable micro-level computations. Just like the overall platform is a composition of several such micro-services, the data architecture allows higher order insights to be built by composing and combining the micro-level telemetry and data products. Telemetry is generated during system usage based on interactions between the users and the system, or between subsystems. Telemetry represents a fact emitted via an event stream, and is immutable. Any additional derivations from the raw fact generate new events. All learning services shall emit telemetry (telemetry can be implemented across all building blocks for understanding interaction behavior in an anonymised fashion).

Open telemetry specification implemented in DIKSHA provides the fundamental definition of what the event represents, what attributes it must have and a guideline on when to generate it. The telemetry specification is a formal contract. It allows the apps that generate events to be decoupled from the data products that process them by standardising the structure and semantics of the events.

Based on the raw telemetry data, data products are developed as services. Data products read the data from the telemetry datastore, run the aggregate computations, and generate output that is stored as derived metrics or published for downstream processing. Derived metrics are available via on-demand APIs or as exhaust. In-line with the microservice architecture, data products can also be seen as micro-computations that can be assembled together to achieve a deeper insight from the data. All derived metrics and data sets shall be available via APIs for building visualisations, running advanced algorithms, and use for policy and research purposes.

10. Reference Applications/Solutions



BUILDING BLOCK CATEGORY

1
BUILDING BLOCKS

REFERENCE APPLICATION/ SOLUTIONS

1. Multi-channel, Unified, Coherent, Accessible applications/solution (Mobile, Web, TV, Phone, Radio, Chat, Voice, Etc)

For enabling core learning- and administration- related interactions in a unified manner to all primary stakeholders, it is important to provide a set of reference solutions as a choice for friction-free access.

The term “reference solution” is used clearly to indicate that these solutions/apps offered as part of NDEAR are just “one of the choices” for the end users. Given the fact that underlying building blocks (learning, administration, registry, etc. described earlier in this document) are API based and NDEAR being an ecosystem-driven architecture, many of the ecosystem partners across Governments, society, market players, and others, will be actively encouraged to build solutions beyond these reference solutions to cater to the diversity of India. This ecosystem-driven solutioning approach is truly the essence of “digital education infrastructure as public good” where many contextual solutions are available to users freely or commercially ensuring choice, contextualisation, and continuous innovation.

UX built as part of reference solutions should try to achieve the above by providing multi-channel, coherent experiences (not siloed and broken), across mobile, web, radio, TV as appropriate, in an accessible (supporting accessibility best principles to cater to users with special needs) and inclusive way (taking first time users, language barriers, and digital divide aspects into account).

NDEAR identifies the key access and service delivery points that would be required by the actors of the educational ecosystem. These are mentioned below:

Mobile/Web Applications

A wide range of mobile apps can be built on top of government reference applications by the NDEAR solution ecosystem, including start-ups and existing Education Tech companies. The end user thus has the choice of selecting the app that suits their needs best. DIKSHA is the default reference application for learning interaction within NDEAR. Various other reference applications shall be built as open source and made available either at the Centre or at State/school levels while stakeholders still have the ability to build their own or obtain a solution from the market.

Television (TV) & Radio

Television and radio are widely prevailing mediums for transmitting digital educational programmes / lectures to the ecosystem actors. While it is essential that these mediums are used to ensure children get access to good content, it is also essential to ensure coherence via allowing seamless interplay between various modes. For example, a programme on TV about a topic could show QR code for users to scan and continue the experience on a smartphone or similarly TV and radio programmes could be made available on web/mobile interface for asynchronous consumption for those who missed out the shows.

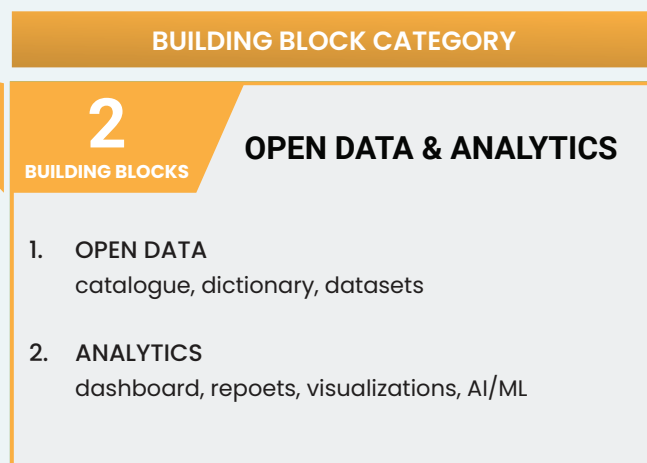
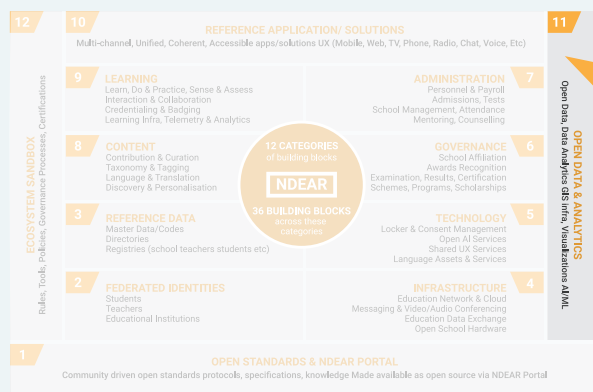
Voice/IVR/SMS

This includes providing voice assistance and transmitting educational programmes / lectures through voice services or VOIP services. Voice-based services shall be available in spoken Indian languages. Similarly, a missed call or an SMS could trigger the system to call back with stories, explanation content, and by sending links to subsequently navigate to alternate channels such as the web. Not only learning services, various administration services such as admissions, certificate requests, etc. can be made available via IVR, missed calls, SMS to help users take actions, get information, etc. without having to physically visit offices, fill forms, etc.

Support Centres

Communities should be encouraged to create local support groups, support centres, etc to bridge the digital divide and help users adopt and leverage digital resources and interfaces. Considering India's vast diversity in language and contexts, central call centres do not work well and are not a viable scalable model. Instead, these support centres should be designed as federated and made as local as possible. Community members and entrepreneurs (similar to ASHA workers (Accredited Social Health Activist) in healthcare or banking correspondents in the financial domain) should be encouraged to join and provide support to users. Interactive chatbot shall be encouraged for responding to frequent queries, get access to information, and conduct transactions.

11. Open Data & Analytics



For effective and quick decision making, it is essential to have a business intelligence architecture block that will assist the governance team in making necessary changes in on-going schemes, along with introducing new initiatives across 3 administrative levels - Centre, State/board, and school.

The following services should be built to be reusable and open sourced. This will ensure that these can be used within other building blocks, and still be deployed in a federated deployment architecture, without having to take an entire analytics solution. These are not to be built as monolithic applications or portals, since data should not be pooled centrally to be able to use the following services; rather these services should be deployed where the data is to ensure data privacy and security. Annexure 3 for more details.

Anonymiser

The Anonymiser service implements various data anonymisation techniques, including deidentification, masking, randomisation, etc. so that applications wanting to “emit” open data for analytics purposes can anonymise various datasets in a standard and efficient manner. Best practices and standards shall be based on international standards such as ISO and work already available from areas like EU General Data Protection Regulation (GDPR) This service receives data from the Education Locker and/or other Education data sets, removes all personally identifiable information to protect the privacy and provides anonymised data to the seeker.

Education Analytics & Visualisation

The objective of this technology component is to provide decision support to the stakeholders on a wide variety of themes i.e. Quality of Education, Quality of Data, Public Education and Policy etc. by analysing the aggregated datasets to be accessed from various systems, through reusable analytics and visualisation services. These services from this building block shall be available freely to various applications to embed within them, to leverage data and analytics within the application context and provide actionable insights to users for taking decisions.

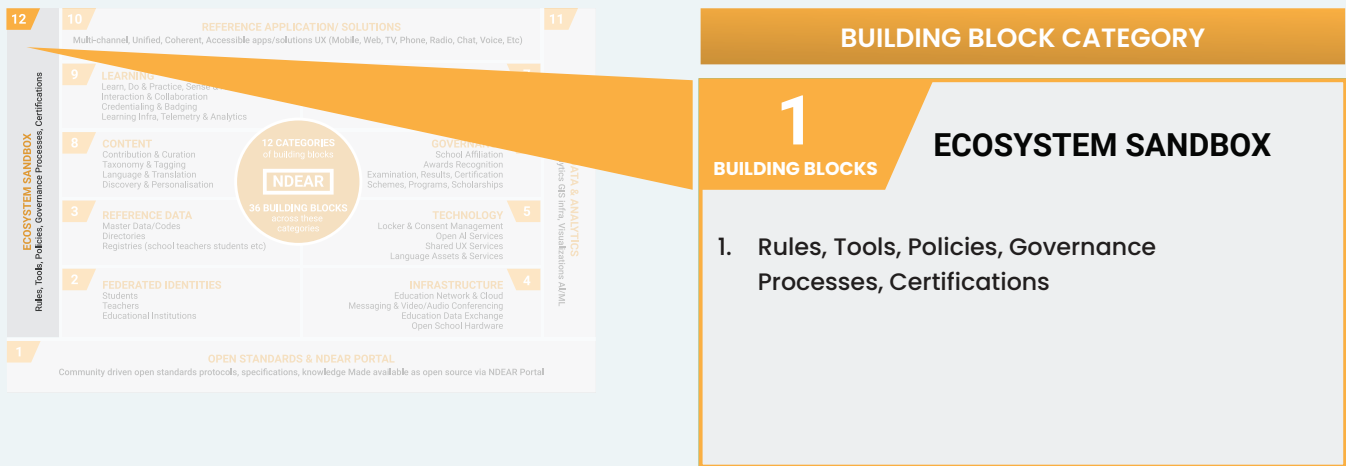
Education GIS Services

Visualisation of data in a map form, enabling location aware services (e.g. finding nearest test centre), etc. requires underlying geographic information system (GIS) capabilities. This is one of the essential reusable services/components within this building block that can enable various applications to embed map visualisations and location-aware services easily without having to build from scratch.

Open Education Data

As per MeitY National Data Sharing Policy (NDSP) and the policies regarding Open Government Data (OGD), it is important that various anonymised datasets (non-sensitive and non-personal data) are made available publicly in an easily consumable form. NDEAR architecture embraces full adoption and implementation of NDSP in the education domain. Various applications in the education domain shall emit all such open data as part of their applications in machine-readable form (CSV, JSON, XML, etc) and ensure these are available to all other applications and ecosystems in general, with no restrictions.

12. Ecosystem Sandbox



IndEA 2.0 thinking is all about building a strong ecosystem around digital infrastructure to drive innovation, contextualisation, and solutioning to cater to the evolving and diverse needs of India. NDEAR fully embraces IndEA and its ecosystem architecture across the 3 ecosystems – programme, asset, and solution ecosystems – around NDEAR federated architecture. To ensure easy participation, rapid solutioning, and wide adoption of NDEAR based education infrastructure, an ecosystem sandbox has been identified as a key building block within NDEAR. Ecosystem Sandbox is defined as a unified environment for all ecosystem actors to discover, understand, engage, experiment, innovate, and build on the NDEAR infrastructure. More on Ecosystem Sandbox can be read in Annexure 3.

2.5. Recommended Standards and Specifications

NDEAR envisages the evolution of an entire ecosystem in the education sector to provide a wide range of services to the stakeholders in a digitally enabled manner. Such seamless and boundary-less interoperability is possible only if all the building blocks and the digital systems are built using the defined standards which are openly licensed, accessible, and usable by the whole ecosystem.

The objective of this section is to identify the standards required for ensuring interoperability and portability within the National Digital Education Ecosystem. It is proposed to recommend a set of minimum viable standards in the initial stages. The scope of the standards is defined keeping the foregoing in view. The table below depicts the areas chosen to define the standards for NDEAR.

Category	Purpose
Learning Environment	Standards related to schools and other learning environments and its evaluation
Consent	Consent from students/ parents need to be covered from two perspectives – consent for data collection and for data use
Content	Standards related to educational content creation
Interoperability	Standards related to exchange of education data
Assessments and Results	Standards related to assessments and harmonisation of marks
Privacy & Security	Standards related to data privacy (through access control) and security of data at-rest and at-motion. Also, aspects such as data immutability and non-repudiation with audit trail
Application design and development	Standards related to design and development of applications

Standards for Learning Environment

Currently, education is not limited to schools. Students have multiple choices with regard to modes for education, each requiring their own learning environment. It is important to understand various learning environments and set up standards that will help in imparting effective education across these learning environments. Standards shall also help to evaluate the learning environment, including formal and non-formal education systems.

Purpose	Applicable Standards
School Standards and Evaluation Standards	School standards and evaluation standards of National Repository of Open Educational Resources (NROER) (https://nroer.gov.in/55ab34ff81fccb4f1d806025/file/59835ec316b51cc4c4db2815)
School Quality Assessment and Accreditation Framework (SQAAC)	As per NEP 2020 (standards will be developed after wide consultations with various stakeholders)
Teacher Education	Governance of National Professional Standards of Teachers (NPST) as per NEP 2020 (standards will be developed by 2022, by the National Council for Teacher Education in its restructured new form as a Professional Standard Setting Body (PSSB) under the General Education Council (GEC), in consultation with NCERT, SCERTs, teachers from across levels and regions, expert organisations in teacher preparation and development, expert bodies in vocational education, and higher education institutions)
Early Childhood Education	National Curriculum framework as per NEP 2020 (The formulation of a new and comprehensive National Curricular Framework for School Education, NCFSE 2020-21, will be undertaken by the NCERT. By 2021, a new and comprehensive National Curriculum Framework for Teacher Education, NCFTE 2021, will be formulated by the National Council for Teacher Education, NCTE in consultation with NCERT)
Adult Education	National Curriculum framework as per NEP 2020
Smart Classroom	ISO/IEC CD TR 4338 (under development)
Collaborative Technology	ISO/IEC 19778-1:2015

Learning Environment Components for Automated Contents Adaptation	ISO/IEC TR 20821:2018
International Communication In Information Technology for Learning, Education and Training	ISO/IEC 2382-36:2019 Information technology – Vocabulary – Part 36: Learning, education and training

Standards for Consent Management

The consent of citizens is crucial in ensuring that collection of data is done in a manner consistent with the legal rights of students/ parents. It is also important to ensure that, once collected, the data captured is used and disclosed (in an identifiable or anonymised form) in a manner appropriate in law and preserving the citizen-directed constraints. Towards these, the standards shown in below table are recommended for designing the systems and workflows required for consent management:

Purpose	Applicable Standards
Consent Framework	Electronic Consent Framework (Technology Specifications v1.1) with its subsequent revision(s) published by MeitY
Online privacy notices and consent	ISO/IEC 29184:2020

The above standard should be implemented in a way consistent with the applicable laws such as Information Technology Act, 2000 (and its amendments) and various directions.

Standards for Content

Standards for content comprises two aspects. One relates to core educational elements that groups of students should know, care about or learn at each grade level and the other relates to quality of the content and content structure, enabling consistency and manageability across various content. The recommended standards for content are mentioned in the table below:

Purpose	Applicable Standards
Question Markup Language (QuML) Specifications	https://github.com/sunbird-specs/inquiry
Metadata elements for describing aspects of curricula	ISO/IEC AWI 23428
Content packaging	ISO/IEC 12785-1:2009
e-textbooks	ISO/IEC TR 18120:2016
Virtual Reality Content	ISO/IEC TR 23842 ISO/IEC TR 23843
Content discovery, Exchange	Standards based on Learning Object Discovery and Exchange Project Group (http://www.imsglobal.org/lode/index.html)
Content Storage	Yet to be identified
Input and Output Standards	
Universal Rubrics	

Interoperability Standards

NDEAR seeks to connect varied systems developed using different technologies and on different platforms by different actors within the ecosystem. The standards should therefore support the integration of all such systems and is necessary to be addressed within NDEAR. Since NDEAR is built on IndEA principles, interoperability recommendations of IndEA also apply.

The following are recommended interoperability standards:

Purpose	Applicable Standards
School Location – Rural and Urban	Metadata & Data Standards – Local Government Directory
Metadata and Data Standards for School Education	Under Development– STQC
School Interoperability	Schools Interoperability Framework followed by US, UK etc. (http://specification.sifassociation.org/Implementation/US/2.5/html/index.html)
Learning Analytics Interoperability	ISO/IEC TR 20748-1:2016
Metadata for Learning Resources	ISO/IEC 19788-1:2011
Metadata for Facilitators of Online Learning	ISO/IEC DIS 23127-1
Emitter Standards for Records	To be developed

Assessments and Results

Assessments are tools to understand a student’s educational progress and achievement. However, India has multiple Education Boards and assessment systems which are not comparable with each other. So, it becomes difficult to judge the performance of students assessed by one system with respect to another system. There is a need to standardise assessments/ results so that each and every student is assessed through a standardised system, comparable to one another.

Purpose	Applicable Standards
Credentialing	Open Badge is a type of digital badge that is verifiable, portable, and packed with information about skills and achievements. (https://openbadges.org/) Generic credential standard (https://www.w3.org/TR/vc-data-model/) Academic & skill credentials (https://github.com/sunbird-specs/inCredible)
Student Education Record (Harmonisation of marks)	Suggested in the NDEAR meeting, it is an academic bank of credit.
Structured Assessment Information Exchange	To be defined.
Student Competence Record	It will help in transferring any competency gained from one app provider to another. To be defined.
Transfer Certificates and Migration	To be defined.

Standards for Privacy & Security

Preservation of privacy is an important consideration that needs to be incorporated in the overall design and implementation of the NDEAR. The standards and various operational requirements for privacy and data security are specified in the table below.

Purpose	Applicable Standards
Security	Digital Certificate, TLS /SSL, SHA-256, AES-256
Access Control	esign (http://cca.gov.in/eSign.html)
Mobile Security	OWASP Mobile Security Testing Guide
Electronic Credential Specifications	Generic credential standard (https://www.w3.org/TR/vc-data-model/ Academic & skill credentials https://github.com/sunbird-specs/inCredible)
Personal Data Access - DEPA	(http://niti.gov.in/sites/default/files/2020-09/DEPA-Book_0.pdf)
Personal Data Protection Bill	(https://www.prsindia.org/billtrack/personal-data-protection-bill-2019), or in the form once notified under law
Certificates / Assessments Storage in Digi locker	Digital Locker Technology Framework (Version 1.1) (http://dla.gov.in/sites/default/files/pdf/DigitalLockerTechnologyFramework%20v1.1.pdf)
Anonymisation	ISO 29100:2011

In addition, it is important to ensure that data is reliable and verifiable. Provisions and guidelines related to the following should be incorporated in operational aspects of the NDEAR:

Purpose	Reasons
Immutability	Records once created cannot be deleted or modified without following due process.
Versioning	Any record created may be 'amended', with the provision of a new version number of the same record. All previous records to be marked inactive, with only the highest version considered active.
Non-Repudiation	All created records must be traceable to its creator unambiguously.
Audit Log	All creation, amendments, access of records should be audit logged in a manner that is verifiable and reliable.
Parent / Student Control	Parents/ students should be able to access/view their own education records anytime, and control access by others.

Standards for Software Design and Development

Software design and development standards shall ensure that software's architecture and design is compliant with common minimum practices and shall enable it to grow as a quality product. Standards will ascertain that software is standardised, compatible and interoperable with other systems.

The following are recommended standards:

Purpose	Applicable Standards
Digital Service Standard	Digital Service Standard, MeitY
Open Data Sharing	The Open Government Data (OGD) (https://data.gov.in)
Framework for Adoption of Open Source Software in e-Governance Systems	Meity Guidelines
Quality Management, Assurance and Metrics	ISO/IEC 19796-3:2009 ISO/IEC 40180:2017
Mobile Governance	Framework for Mobile Governance, MeitY
Guidelines for Indian Government Websites	https://web.guidelines.gov.in/
Web Standards for Accessibility (Web and Mobile)	World Wide Web Consortium (W3C) (https://www.w3.org/)
Guidelines for the development of e-Governance Applications	GudApps (https://guidelines.gov.in/gudapps/about.html)
Open API	Meity Guidelines
Localisation and Language Support	MeitY Guidelines
Geo Spatial Data Product Standardisation	ISO 19115, FGDC Content Standard for Digital Geospatial Metadata (CSDGM)

3.1 Overview

NDEAR is envisaged to play a catalytic role towards the achievement of NEP 2020 goals by providing a fertile ground for innovations in the education ecosystem. Given the rich diversity of available resources, governance institutions within the education ecosystem, it is imperative to create a nimble and agile institutional framework in place, so that the ambitious role envisaged for NDEAR, of energising, unifying and catalysing the ecosystem, can be accomplished.

The implementation of NDEAR vision and principles will result in wide adoption by the ecosystem of Centre, State, public, non-profit, private as well other stakeholders. This needs clear definitions of the roles and responsibilities of various institutions for the long term sustainability of NDEAR institutional setup. This section explains and recommends an institutional framework that may be adopted for NDEAR.

In examining an effective institutional framework for NDEAR, an analysis was conducted to derive learnings from existing institutional frameworks, both national and international:

- Of analogous digital infrastructures created in other sectors in India - GSTN, NPCI, UIDAI, National Digital Health Mission/ National Health Authority
- Existing national organisations within the education ecosystem (that may also have the potential to subsume part of NDEAR mandate) - NCERT, CIET, NIC, envisioned NETF, envisioned RSA
- Global organisations managing education digital initiatives - BECTA, KERIS, Pustekom

Refer to Annexure 4 for the detailed analysis.

3.2 Purpose and Objective of Institutionalisation

The institutional structure for NDEAR was examined in light of the vision and objectives of NDEAR, as laid out in the scope of NDEAR. The purpose of the institution would be to realise the vision of NDEAR as:

“A unifying national digital infrastructure to energise and catalyse the education ecosystem.”

- Which is Federated, Unbundled, Interoperable, Inclusive, Accessible, Evolving
- To deliver Diverse, Relevant, Contextual, Innovative Solutions

Therefore, the objective of the institutional structure for NDEAR would be :

“To **orchestrate, catalyse and support** the education and digital ecosystem in the development and adoption of a national digital educational infrastructure to achieve the objectives of and fulfil the vision of NDEAR”

3.3 Guiding Principles for Institutional Structure for NDEAR

Some of the overarching principles laid down in the scope section of the NDEAR blueprint are applicable to the institutional framework as well:

- a. Minimal Footprint
- b. Evolvable and Agile
- c. Federated and Inclusive (Centre - State - Public - Private - NGO)
- d. Enable and catalyse through multi-stakeholder ecosystem

3.4 Essential Elements of the NDEAR Institutional Framework

A few essential elements that need to be carefully considered while designing the institutional framework for NDEAR:

- a. Mandate – The scope and vision of the entity.
- b. Legal constitution – The nature (statutory, autonomous, non-profit etc), ownership and autonomy of the entity.
- c. Composition and Governance Structure – The composition of the entity and representation of diverse stakeholders (with appropriate experience and skill sets) across leadership, advisory and functional verticals, such that it ensures that the entity is set up for success.
- d. Roles and responsibilities/services offered – The roles and responsibilities charted out for the entity should reflect the mandate very clearly. The nature of responsibilities created in the first instance would be critical in ensuring that the NDEAR organisation can easily take an agile approach and continue to adapt to the rapidly evolving world of technology as well as changing needs of the stakeholders.
- e. Funding – The mechanism to fund the entity for its operations should be such that consideration is given to its independence in decisioning and functioning to realise its vision as well as its long term sustainability, while financially supporting its formation and incubation till it reaches a steady state of operations.

3.5 Roles and Responsibilities of the Institution

1. Ecosystem – Catalyse and Energise the Education Ecosystem:

- a. To achieve the objectives of NDEAR as articulated in the blueprint and as it evolves from time to time and realises the vision of NDEAR.
- b. To contribute to and to leverage digital infrastructure for the education in the development of innovations and solutions for the full continuum from pre K-12 to higher education and related fields like skilling, employability, etc.
- c. By promoting the adoption of NDEAR by GoI, States, Private/ NGO Sectors.
- d. By engaging the ecosystem through events, hackathons, innovations, fests and other such outreach, engagement and development programmes.

2. Building Blocks:

- a. Enable and orchestrate the development, creation and evolution of the building blocks of NDEAR.
- b. Identify and share best practices in the use of NDEAR compliant building blocks to create diverse solutions.
- c. Identify and share innovations and solutions compatible with NDEAR building blocks, use of open data in education and improvements in efficient governance processes.

3. Standards, Specifications and policies: Develop, Support, Publish, Curate, Frame:

- a. Standards, specifications and policies in the areas of technology for education, open data and protection of data of individuals (particularly children) and for a thriving and innovative education ecosystem.
- b. Specifications of core, common, reference and other building blocks.
- c. Setting up standards for the establishment and management of registries which will be a single source of truth for students, teachers, courses, institutes, credentials etc.
- d. Rules and tools for fostering innovation and development of diverse solutions by energising the education ecosystem of government, civil society and the private sector.

4. Innovations, Solutions – Encourage, Promote, Incentivise, Support, Facilitate, Support the Development of:

- a. Diverse solutions and innovations by leveraging emerging technologies for the education ecosystem including but not limited to AI/ML, AR/VR, etc.
- b. Reference solutions for NDEAR by leveraging building blocks of the digital infrastructure.
- c. Ecosystem Sandbox along with engagement frameworks, rules, and tools.

5. Capacity Building & Change Management

- a. In relation to NDEAR Architecture, Ecosystem Architecture, Ecosystem Technologies, Content Development.

3.6 Legal Constitution

Given the vision, evolvable nature and diverse expertise required for NDEAR, the institution may be created as an autonomous entity under the aegis of the MoE as the parent body. The multi-stakeholder and ecosystem approach must be reflected in the institutional framework, with the involvement of non-profit and private sectors engaged in education, skills and lifelong learning domains, technology and innovations domain.

Strategic control may remain with the Government; diverse representation and participation will foster innovation and will help NDEAR in staying ahead of the curve in many domains. Such involvement will augment the ecosystem approach of NDEAR and will ensure wider adoption of NDEAR, by the education ecosystem, which will include not only the Centre and State governments and their allied institutions but also other non-profit and private entities. It is also envisaged that the regulatory role will remain with the MoE or the entity which already has been mandated with the role.

An evaluation of the current institutional presence for education in India highlights significant gaps in their capacity or flexibility to accommodate the vision for NDEAR. For instance, MoE focuses primarily on policies governing education technology in India and CIET, originally set up as a premier institute to promote the use of technology in education, has been focusing on content creation, curation, delivery and training. Therefore, a new autonomous body may be required to house NDEAR and allow for a strong and diverse leadership. This will enable NDEAR to establish a broad platform for supporting and interfacing with existing institutions and adapting to the emerging needs of the ecosystem.

3.7 Governance

Governing board: with representation from the Centre, autonomous bodies, State governments, non-profit and private sector. This will include experts from the education sector and technology sector.

The governance structure for NDEAR needs to ensure that it is a nimble organisation with a minimal footprint that can easily evolve and adapt as per the changes in ecosystem and advances in technology to derive maximum value from the creation of the digital education architecture. The MoE may appoint the Chairperson. Autonomy in functioning for NDEAR can be ensured by having a dedicated board of directors/ governing council and providing operational responsibilities to the CEO of NDEAR.

Advisory Board: A multi-disciplinary board that may comprise experts and persons of experience and exposure in diverse fields, not limited to education and technology, and can bring varied perspectives to enrich the thinking of NDEAR.

Chairperson: The Chairperson for NDEAR may be appointed by the Government and could be an officer of the rank of Additional Secretary or Joint Secretary from the MoE. This will ensure strategic control of the government over NDEAR.

Chief Executive Officer (CEO): The CEO should ideally have experience at the cross-section of education and technology. If this person has experience with ecosystem-building and managing large-scale digital initiatives in parallel sectors, that would be of added value. A transparent process that allows for identifying a suitable candidate with cross-sector experience may be set-up. The role of the CEO would be to develop the strategies and lead the organisation to achieve the objectives of NDEAR, under the guidance of the Board.

Chief Technology Officer (CTO): Technology applied to education will be at the core of NDEAR. This includes most of the activities under the ambit of NDEAR, such as planning & creation of educational content, outreach, on-boarding of educational institutions, partnerships with stakeholders, delivery of education, developing technology building blocks and enabling technology to utilise educational resources optimally. The CTO will advise the CEO and lead the strategic technology thinking on how to use technology building blocks to achieve NDEAR objectives. The CTO will need to have experience in the latest population scale technology architectural thinking and understanding of the developments in the relevant cutting edge technologies like AI/ ML, open-source, cyber security, etc.

Like the ever-evolving nature of technology itself, NDEAR would be an evolving ecosystem with multiple building blocks and will continue to develop and mature through the efforts of multiple ecosystem partners, including civil society and private players. Continuous compliance with architectural principles and standards prescribed is also a challenge during implementation. Technology implementation, sustenance, upgradation, and knowledge transfer is a continuous process and can only be sustained with stable top-level in-house expertise. Strategic control of the core technology that is used within the Government infrastructure is critical. Organisation such as the National Informatics Centre (NIC), which has decades of experience in the application of IT in different domains of education at the Centre as well as State & District level, can be given the responsibility to ensure the Government has strategic control of core technology, ensure its compliance with rules & regulations, particularly from an openness and data protection perspective.

3.8 Funding

The parent ministry (MoE) is to make provision of appropriate funds for realising NDEAR's mandate and running day-to-day operations for the initial 4-5 years. In the long term, a phased transition can be planned for NDEAR to move to a self-sustainable, revenue generating model (not-for-profit model). Potential revenue streams may include (but not limited to) monetising reference applications and services it provides to other ecosystem players. Alternatively, it can also accept grants and aids from outside the parent ministry, and philanthropic contributions in funding or resources and assets for reduced dependence and increased sustainability. A self-financing model may also drive service orientation for NDEAR and provide incentives to continuously innovate and respond to the needs of beneficiaries. This should ideally be accomplished without compromising the essential defining trait of NDEAR building blocks being available as a public good.

3.9 Recommended Entity Structure

The NEP 2020 envisages the creation of an autonomous body, the National Educational Technology Forum (NETF). The aim of the NETF will be to facilitate decision making on the induction, deployment, and use of technology, by providing to the leadership of education institutions, State and Central governments, and other stakeholders, the latest knowledge and research as well as the opportunity to consult and share best practices.

In light of the NEP 2020 and given the stated need to focus on technology for learning and the proposed setting up of the NETF, NDEAR may be housed as a centre under NETF or as a unit of NETF, if there is a coherent fit, else a separate institution for NDEAR could be set up as a SPV.

3.10 NDEAR Programme Management Unit

Even as the larger institutional framework may take time to fully fructify, to roll out the vision of NDEAR and also to set up demonstrative examples of what NDEAR envisages to do, the MoE would like to proceed with projects and programmes under the NDEAR framework with immediate effect. To immediately start working on NDEAR, a dedicated Programme Management Unit (PMU) will be set up. PMU shall be staffed with specialised consultants for the development of a roadmap for NDEAR implementation, identification & prioritisation of work, budgetary estimation, design, monitoring and follow up on the progress of NDEAR implementation. PMU should also provide opportunities for volunteers from the industry to join for a stipulated time.

Governance:

PMU shall initially work directly under the MoE until the NDEAR institutional set up is ready.

A Project Steering Committee (PSC) shall be set up to provide, review and monitor strategic direction and policy guidance to the PMU and other stakeholders. The PSC will provide direction to the efforts of the operations group, including the PMU, and will consist of representatives from Government and non-government organisations/ private organisations and experts in the field of education and technology. It should also have professionals from the fields of education technology, open source technologies, education, education programme implementation, data protection and privacy and other related areas, as decided by the PSC. To expedite the implementation of NDEAR by the PMU, the PSC may set up a Review Committee which shall, within the strategic direction provided by the PSC, review, approve and give necessary guidance to the work being done by the PMU on a regular basis.

Funding:

PMU shall be supported by MoE initially, till the formation of the NDEAR institutional setup. However, after establishing the NDEAR institutional set up, PMU shall be funded by, and absorbed into, the NDEAR institutional setup.

Duration:

PMU as is proposed above, may function in this mode, till the time the institution for implementing the vision of NDEAR is set up. Thereafter, it shall come under the aegis of the institution.

Skill sets of the PMU:

PMU shall have professionals with varied skill sets, as outlined below or as decided by the PSC. The key requirements of positions will be:

- Project Management Expert having project management experience of large-scale IT project implementation experience in the Government sector.
- Procurement Expert with knowledge of Request for Proposal (RFP), Business Process Re-Engineering (BPR), Detailed Project Report (DPR) preparation and Bid Process Management.
- Subject Matter Expert with domain knowledge of the school education sector.
- Technical Expert(s) having experience of policy, standards, specifications and policies in the areas of technology for education, technology and data, ecosystem architecture, ecosystem technologies, development and maintenance of large-scale IT projects.

To initiate the process, as NIC is working on a number of projects like Samagra Shiksha, FLN, UDISE+ with MoE, it could provide a senior NIC officer with extensive experience in the technology and education sector, supported by a team of 3-4 officers to the PMU, and the manpower/ agency could be sourced from the market. Volunteers and resources seconded from private sector organisations, NGOs and philanthropic organisations may also be selected in full-time or part-time positions.

Roles and Responsibilities:

A dedicated PMU in NDEAR will be working on the operationalisation and roll-out of NDEAR across the country and shall be responsible for the following, under the guidance of the PSC:

Area of Responsibility	Key Activities to be performed
<p>Prioritisation and Implementation Strategy Building</p>	<p>At the outset, the PMU will prioritise areas identified by the MoE, including but not limited to policies, programmes and platforms such as Samagra Shiksha, Foundational Literacy and Numeracy, Early Childhood Education etc.</p> <p>PMU shall help in prioritising the areas of implementation, defining the roadmap, milestones and granular implementation strategy of NDEAR.</p> <p>Support for preparation of a detailed action plan and project fund requirements.</p>
<p>Building Blocks</p>	<p>Define further the specifications of the building blocks and identify existing core, common, reference and other building blocks.</p> <p>Support for design, development & implementation of core, common and reference building blocks. Preparing requirements and implementation guidelines.</p>
<p>Registries</p>	<p>Setting up standards for establishment and management of registries, which will be a single source of truth; building reference applications for registries for students, teachers, credentials and schools.</p>
<p>Data Policies</p>	<p>Standards, specifications and policies in the areas of open data, privacy and protection of data of individuals (particularly children).</p>
<p>Reference Solutions</p>	<p>Create reference solutions, where ever required for the selected areas/ projects/ programmes taken up.</p>
<p>Requirement and Integration Management</p>	<p>Support in capturing and analysing the requirements, suggesting business process improvements, conducting the feasibility and finalising the requirements.</p> <p>Support the processes and activities needed to identify, define, combine, unify and coordinate the various processes and activities.</p>
<p>Programme & Project Management</p>	<p>Support overall management of the programme and other projects of NDEAR implementation.</p>
<p>Procurement, Contract and Vendor Management</p>	<p>Procurement of service provider(s) for core, common & reference building blocks and reference solutions [Request for Proposal (RFPs), Business Models, service level agreements (SLAs) etc.], where ever required.</p> <p>Shall support to make effective use of people involved with the project such as organisational planning, staff acquisition and team development.</p>
<p>Relationship & Communications Management</p>	<p>Ensure a shared understanding of the vision of NDEAR and its implications among all key stakeholders.</p> <p>Engage the ecosystem through events, hackathons, innovations, fests and other such outreach, engagement and development programmes.</p>
<p>Knowledge Management</p>	<p>Support process to achieve a centrally managed repository for all the information gathered and produced over the life of the project/ programme.</p>

4.1 Context

As per the NEP 2020,

“The highest priority of the education system will be to achieve universal foundational literacy and numeracy in primary school by 2025. The rest of this Policy will become relevant for our students only if this most basic learning requirement (i.e., reading, writing, and arithmetic at the foundational level) is first achieved. To this end, a National Mission on Foundational Literacy and Numeracy will be set up by the Ministry of Human Resource Development (MHRD) on priority. Accordingly, all State/ UT governments will immediately prepare an implementation plan for attaining universal foundational literacy and numeracy in all primary schools, identifying stage-wise targets and goals to be achieved by 2025, and closely tracking and monitoring progress of the same”.

The MoE aims to achieve Foundational Literacy and Numeracy by 2025, whereby Grade 3 every child should be able to read 30–35 words per minute with comprehension; write; do basic math operations. In addition, the MoE recognises the need for parental involvement and community and volunteer participation in the achievement of the FLN goal (NEP 2020).

In this context, NEP 2020 also talks of the importance of leveraging technology for education and especially the creation of content repositories and access to a wide range of teaching and learning content. It is in this context that the role and support of NDEAR to achieve the FLN mission of MoE must be envisaged.

4.2 Goals of FLN Mission

A National Mission on Foundation Literacy and Numeracy is being set up by the MoE with the following goals:

1. All children in the age group of 6–9 have access to foundational schooling and achieve foundational skills by Grade 3.
2. High quality and diversified student and teacher resources/learning materials are made available for a joyful learning environment.
3. School-readiness module implemented in the local language in Grade 1 in all schools.
4. Teachers of Grades I to V (new) are trained to ensure the requisite capacity to deliver high quality instruction for foundational years.
5. Development of a robust technology enabled-monitoring mechanism (new) to track the progress of each child in achieving learning outcomes.

Every learner should have access to joyful learning experiences that are holistic, keeps them engaged, happy, confident and thinking critically with access to resources such as diverse reading materials and stories in local languages, activities of various kinds and ideas for play and learning. Teachers must be empowered to develop their own innovative aids and tools with local resources for making their classroom transactions engaging and joyful. The FLN mission states a number of such goals to be achieved.

4.3 Activities and Key Performance Indicators (KPIs) related to achieving the above FLN goals

The MoE has identified and elaborated on a set of activities and KPIs for achieving the above goals, for example:

The need for **teaching learning materials (TLM) for implementation of innovative pedagogies (new) (including worksheets/ workbooks, reading cards, supplementary graded materials and activity materials)** is recognised as an activity. Sample KPIs are listed below.

The KPIs for this activity would be the **Development of Core TLM** for reading literacy and mathematics literacy by SCERT in local languages and the percentage of students from the foundational years (Grade 1 to 3) who have access to and use Core TLM. For the above, data would be needed on how many students have access to and use the Core TLM that has been developed.

A second KPI for this activity would be the development/ provisioning of Supplementary TLM as additional resources by SCERT, such as toys, puzzles, puppets, games, boardgames, story books, anecdotes, jokes, local rhymes, local folk songs/lore, art and craft, online access to high quality and engaging e-content related to learning outcomes for Grades 1 to 3 on DIKSHA. For this, data would be the number and variety of content developed and subsequently accessed by students.

A third KPI is the development of **IEC material** or parent communication material regarding the learning outcomes to be achieved by the child, designed in simple and local languages by SCERT. The data points to evidence the completion of this KPI would be the number of times these communications were sent and the number of parents who accessed these communications.

An elaboration of activities and KPIs are stated in Annexure 5.

Building Blocks for Foundational Literacy and Numeracy

In light of the goals, objective and intent of the FLN mission, there are many different solutions that will be required to be used, repurposed and perhaps even built. The NDEAR digital infrastructure would be applicable to achieving the FLN policy goals stated in the NEP 2020. Given the urgent imperative of FLN, the conceptualisation of NDEAR is timely, as the NDEAR open standard and specifications and building blocks may be developed or leveraged to achieve several policy goals.

NDEAR architecture identifies 36 building blocks across 12 categories, 3 ecosystems and 5 personas. These may all be applied in the context of FLN. Solutions, assets and building blocks developed for FLN may be developed to be NDEAR compliant by following the technology architectural principles, data principles, policies and standards, specifications and frameworks of NDEAR. It would be essential to ensure autonomy and diversity through a set of federated systems which are interoperable based on standards and specifications so that from a data perspective there is a single source of truth while at the same time, protecting individual data, privacy and identity.

4.4 Suggested application of NDEAR to FLN

The priorities for FLN are stated in the goals and these can be achieved by leveraging the existing building blocks such as UDISE++ and reference applications like DIKSHA, while these maybe enhanced by leveraging open source tools and solutions for registries and identities, and at the same time following the principles and standards set down by NDEAR.

The following process may be followed:

1. An assessment may be made of existing building blocks that may be upgraded and leveraged for the sake of FLN.
2. The missing building blocks required may be developed to serve the policy goals while following NDEAR principles.
3. The NDEAR institutional framework led by MoE may identify the areas where standards, specifications and policies need to be put in place to achieve the above mentioned policy goals - including open data policies; data protection and children's data privacy and protection policies; data sharing policies; standards for the development of interoperable registries among others; policies for ecosystem engagement.

An illustrative exercise of some of the building blocks that maybe leveraged/ developed for FLN:

	Building Blocks of NDEAR	Digital Infra for FLN
1	National Interoperable Standards and Specifications	Standards for digital credentials, Holistic Progress Card, data emit, question markup language, privacy, data sharing.
2	Technology and Infrastructure	UDISE++; education building blocks, language assets.
3	ID and Registry	Federated Teacher registry, school registry and student registry, scheme registry, content registry, question banks, learning outcomes registry, credentials registry.
4	Learning Services	Diverse content; teacher-skilling courses and materials; sensors that can help in the easy assessment of learning levels; interactive content types, connected with play methods, activity based learning and discovery based learning, early reading facilitation.
5	Data and Analytics	To increase overall observability in viewing and using data for program and solution enhancement. Physical to digital conversion, data capture using AI e.g. Gujarat PAT marks digitisation; ability to connect data across silos.
6	Ecosystem Sandbox	Sandbox, with appropriate policies for innovation around sensors e.g. ORF and assessments, read-along, AI/ML based practice aids.

This note contains an example framework and architecture for FLN data collection and measurement.

4.5 Framework and Architecture for the FLN Data Collection and Measurement

- The overall process of FLN Data Collection and Measurement can be divided into three key phases- Data Collection, Data Connection and Coordinated and Continuous Action (See Figure below)

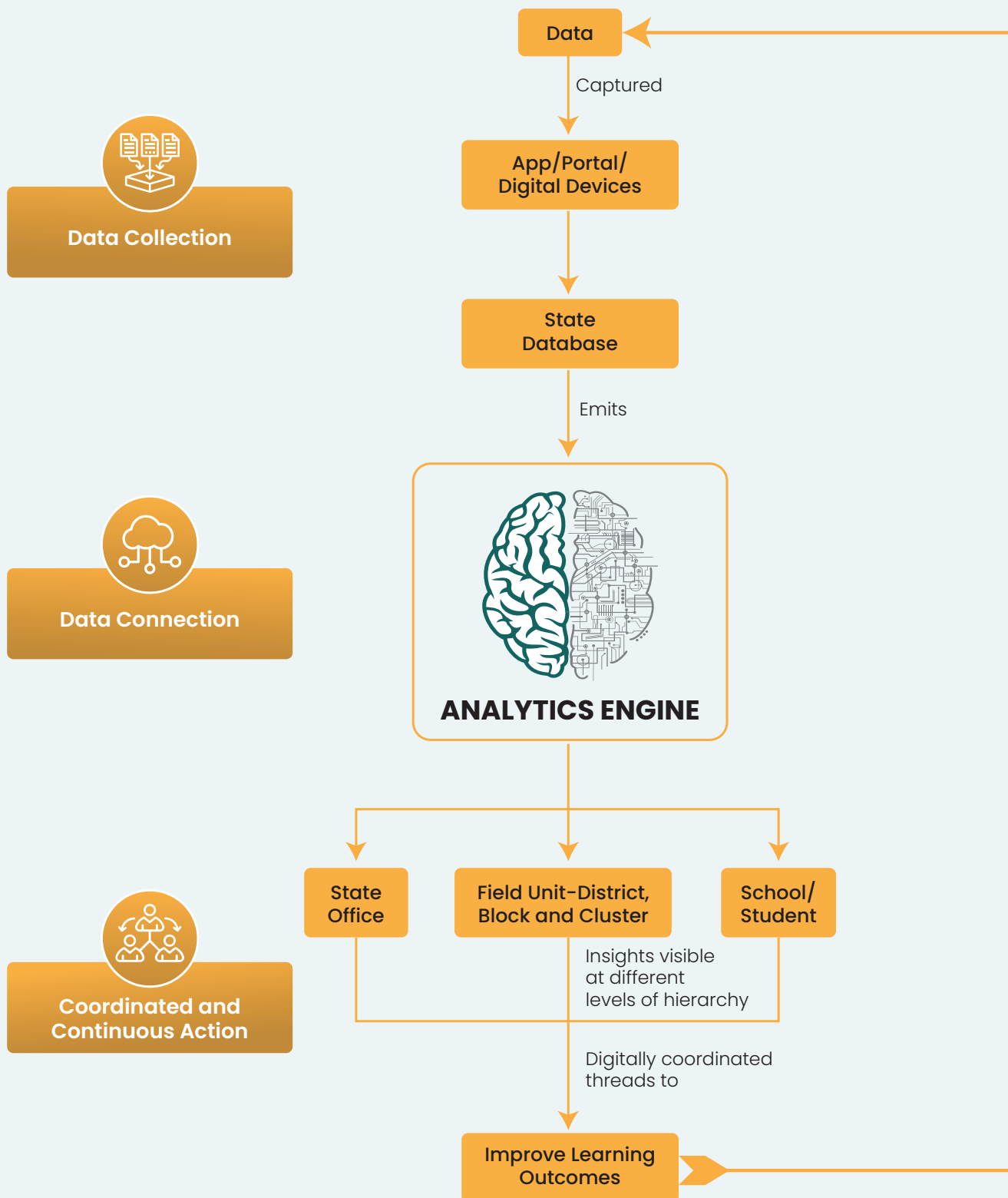


Figure 11 - Data collection and Measurement Process

2. A robust IT (Information Technology) system embedded with big data analytics will be an integral part of the FLN Mission. It will not only be a critical enabler but also an important tool to ensure the success of the mission.
3. The data collection should be done in such a manner that obviates the need for multiple data entries and does not add to the burden of the teacher/schools. Data collection may be enabled through Machine Learning/ Artificial Intelligence tools and may be possible through multiple modes such as websites, mobile apps etc.
4. The data architecture needs to include the following:
 - a. Easy and automated ways of capturing data digitally from schools
 - b. Automated upload of the data to state/national systems
 - c. Emission of such data from the state systems in a standard format amenable to analysis
 - d. Generation of actionable metrics and visualisations by an analytics system
 - e. Automated dissemination of analysis to stakeholders within the education hierarchy to enable timely action
5. The system should enable automatic data collection and collation from multiple sources and at different frequencies and levels without the need for special collection drives, pulling of data from different systems, synchronisation, manual uploading etc.
6. Data Sources

The data required for tracking the progress of children will be generated through four kinds of assessments:

 - a. School based Assessments through Holistic Progress Card
 - b. State level assessment through SAS
 - c. Third party assessments by State
 - d. National level surveys or NAS
7. For school-based assessment of FLN, a student progress card will be designed by NCERT and SCERTs which would be a **holistic, 360-degree, multi-dimensional report of progress**, that reflects in great detail the progress as well as the uniqueness of each learner in the cognitive, affective, socio-emotional, and psychomotor domains as well as in acquiring of life and learning skills, and values. This progress report will be based on self, peer, teacher and parent assessment of various skills and competencies acquired by the child.
8. Child-wise data would be required (collected following norms and laws for data protection particularly PII of children) which would be aggregated and visible through appropriate dashboards at the school, block, district, state and national level.
9. An App based Rubrics is required for a Holistic Progress Card (HPC) to focus on Knowledge, Competencies/ Skills, Attitudes, Values, etc. and AI based analysis. This will utilise the national level HPC prepared by CBSE and NCERT as the basis of developing the state/UT level HPC in the local language.
10. HPC should be such that the teacher has to fill it up at least twice/thrice in a year.
11. SCERT shall also delineate the speed of reading with comprehension in the local language, or Oral Reading Fluency (ORF) for Grades 2 to 8.
12. In addition to school based assessment, there will also be sample based National Achievement Surveys and State Achievement Surveys which will be held in alternate years (NAS in 2021, 2024 and 2027; SAS in 2022, 2023 and 2025, 2026). These surveys would assess the improvement in learning outcomes and would also corroborate the data received from school based assessment.
13. Further, for SAS, third party assessment and NAS, school wise data will be required which can be aggregated through dashboards at district, state and national level.
14. The activities envisaged and their KPIs, along with an indicative list of data points is mentioned in Annexure 5, may be taken into consideration.

5.1 DIKSHA - Building Blocks, Solutions and Road Map

DIKSHA (Digital Infrastructure for Knowledge Sharing) is a national platform for school education, an initiative of NCERT, DoSEL, MoE, Government of India (GoI). DIKSHA has been developed using MIT licensed open-source technology called Sunbird based on the core principles of open architecture, open access, open licensing with diversity, autonomy and choice. DIKSHA contains several building blocks that enable and support various use-cases, multiple languages and solutions for teaching and learning. DIKSHA is constantly evolving and currently could contribute to many NDEAR categories such as Standards, Technology, Content, Learning, Reference Apps and Open Data to name a few.

DIKSHA was developed on the basis of the *Strategy and Approach Paper for the National Teacher Platform* released by the former Hon' Minister for Human Resources Development, Shri Prakash Javdekar in May, 2017. DIKSHA was launched by the Hon' Vice President of India, Shri M Venkaiah Naidu on Sept 5th, 2017 and has since been adopted by 35 states/UT's as well as by CBSE and NCERT and by crores of learners and teachers.

The possibilities of DIKSHA are multifold due to which it has not only witnessed unparalleled adoption in a short span of 3 years but has also played a key role in the digital transformation of India's school education ecosystem.

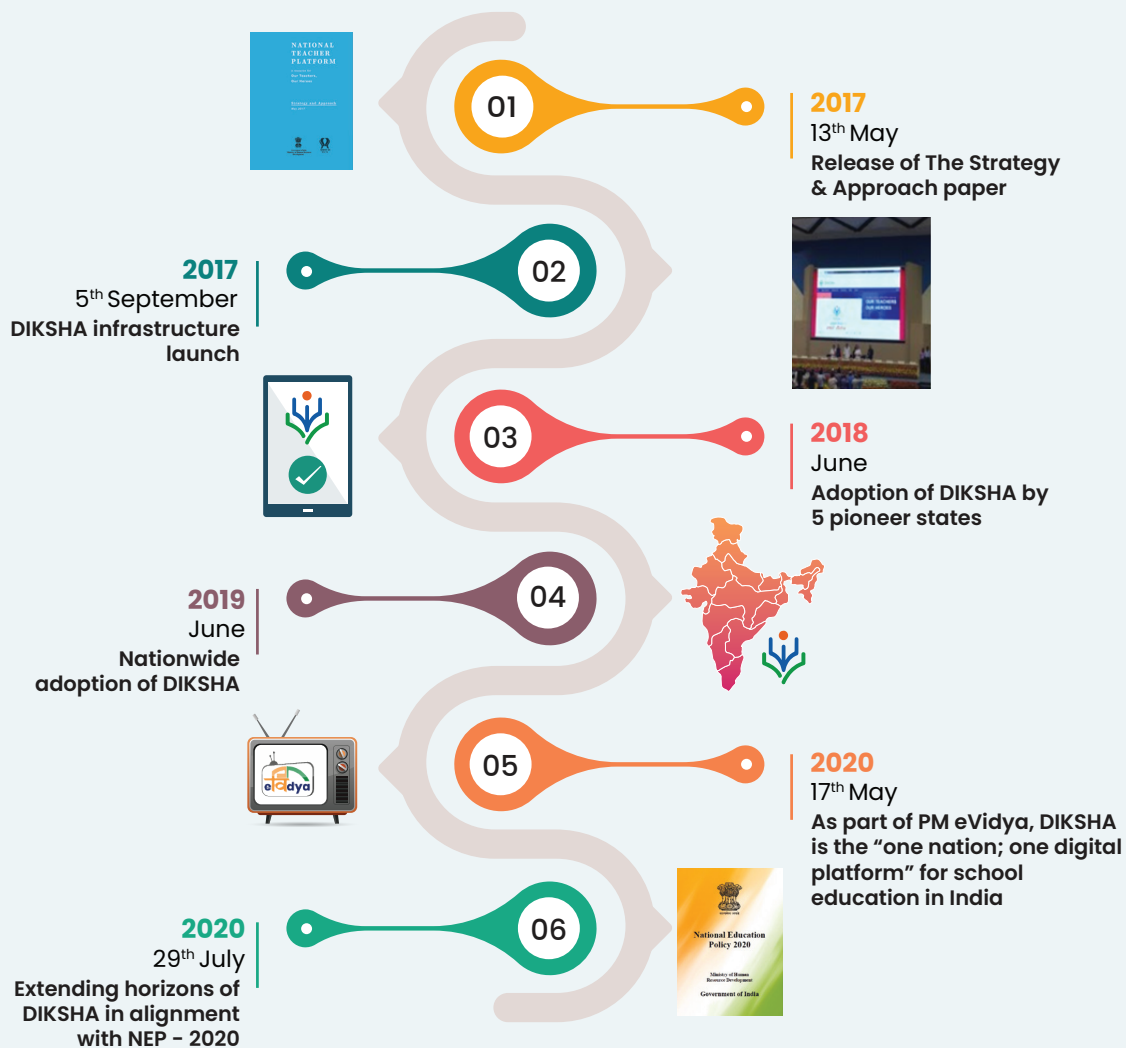


Figure 12: Journey of DIKSHA

DIKSHA embodies, is designed and implemented on the basis of the following ten design principles:

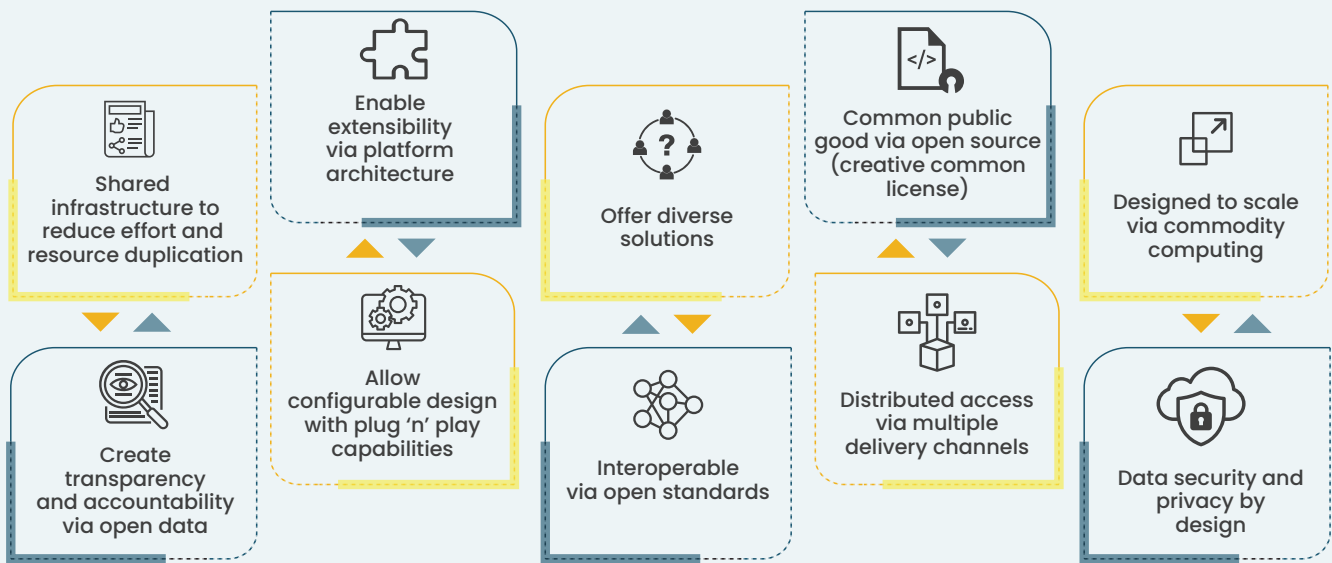
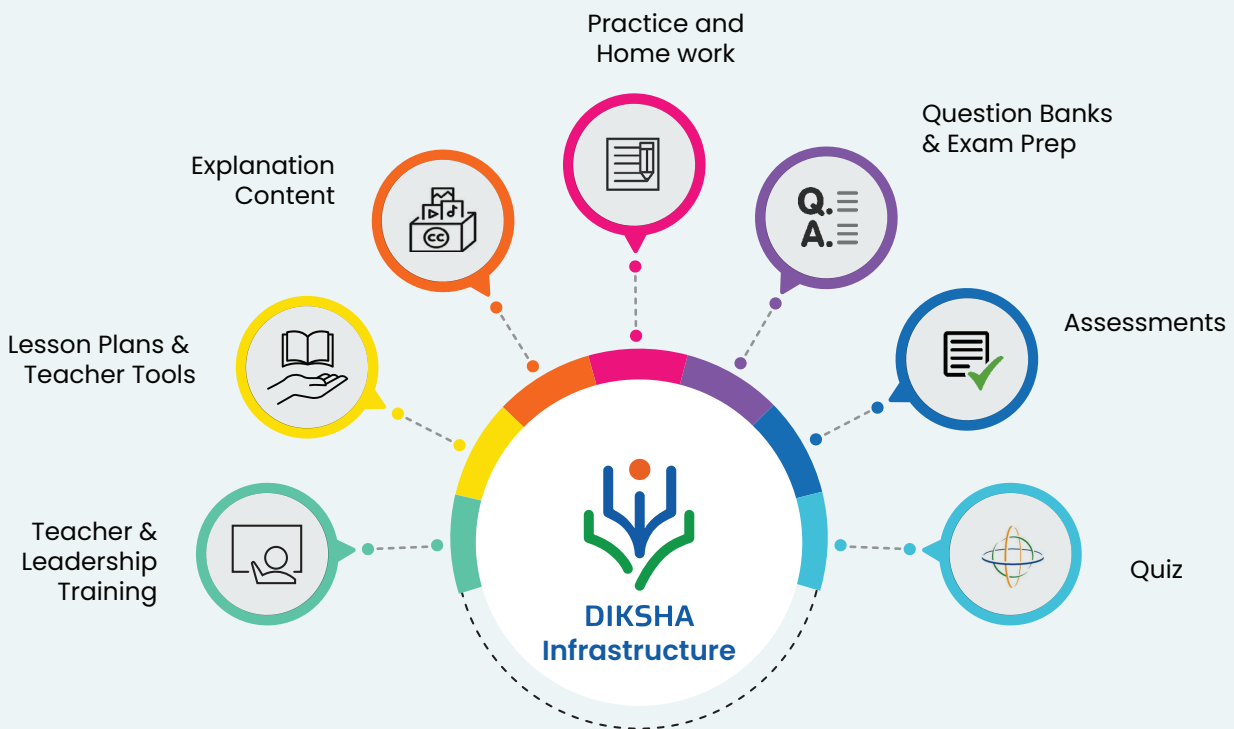


Figure 13. Design Principles of DIKSHA

DIKSHA is available for the use of all States and UTs of India. Each State/UT leverages the DIKSHA platform in its own way, as they have the freedom and choice to use the varied capabilities and solutions of the platform, to design and run programmes for their teachers and learners. DIKSHA policies and tools make it possible for the education ecosystem to participate, contribute and leverage a common platform to achieve learning goals at scale for the country.



One DIKSHA, Multiple Central and State Programmes

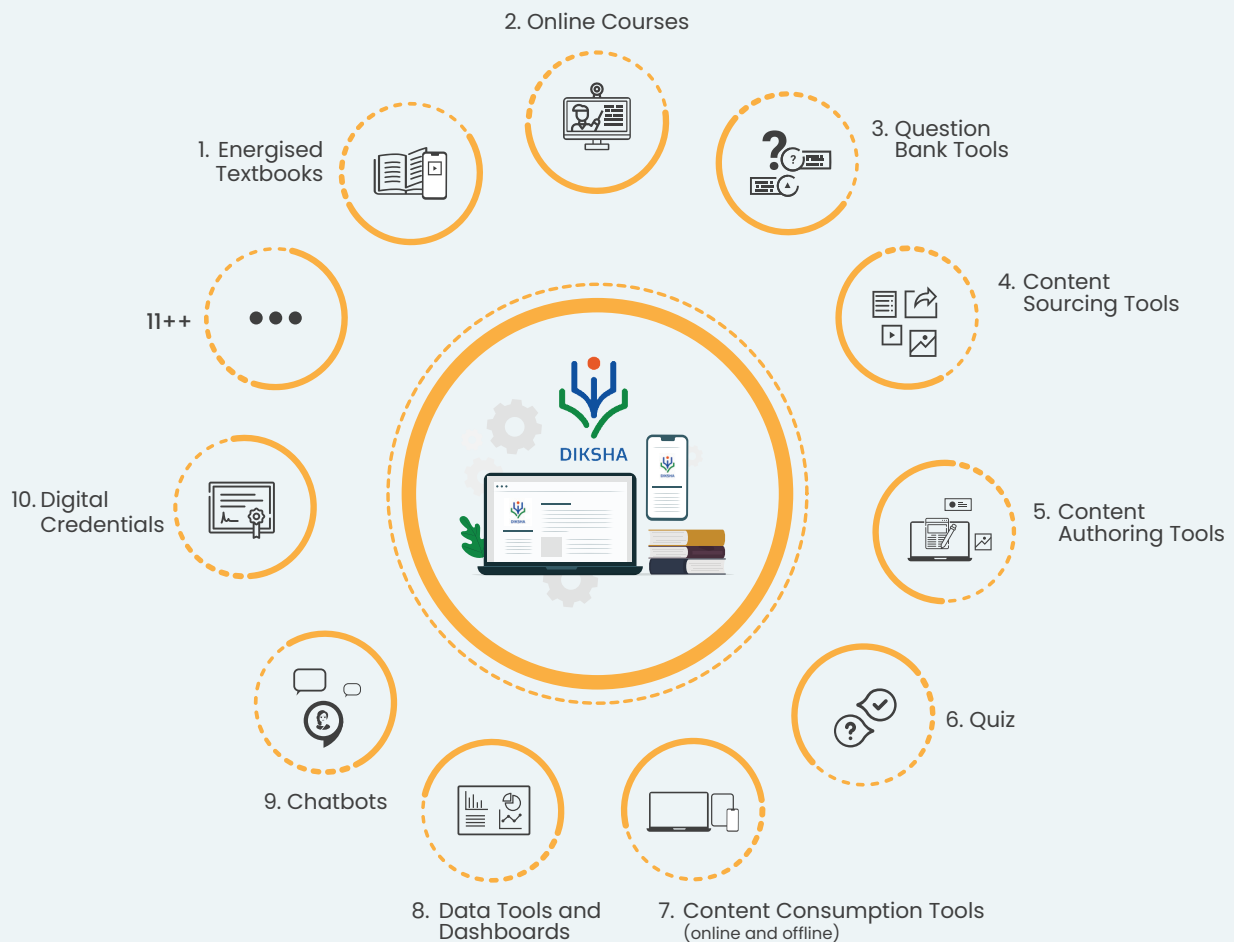


Figure 14 : Solutions on DIKSHA – Diverse, Flexible and Evolving⁹

Education is now increasingly resourced and conducted through digital devices to ensure continuous learning during the COVID-19 pandemic. Schools across the country have moved towards adopting various modes to facilitate teaching and learning at home.

DIKSHA has 1,40,000+ e-content resources available across 30+ languages along with 500+ micro courses for teacher training for easy access and consumption during as well as post lockdown.

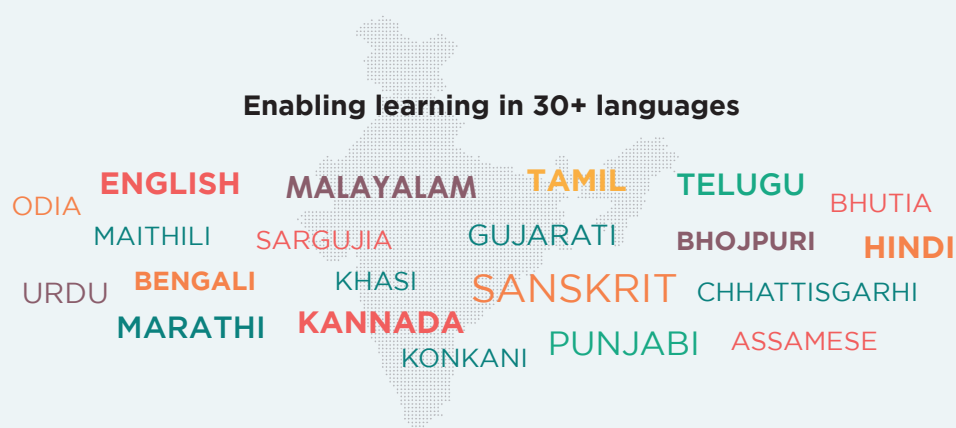


Figure 15 – DIKSHA Enables 30+ languages

DIKSHA witnessed more than 170 Crores learning sessions as of January 2021 which showcases the relevance of the available e-resources as well as the integration of digital learning in the daily lives of teachers and learners across the nation. DIKSHA app has been rated as one of the top rated Free Education App on the Google Play Store in India since May 2020.

⁹Source India Education Digital Report 2020



Figure 16 – See Diksha Dashboard on diksha.gov.in¹⁰

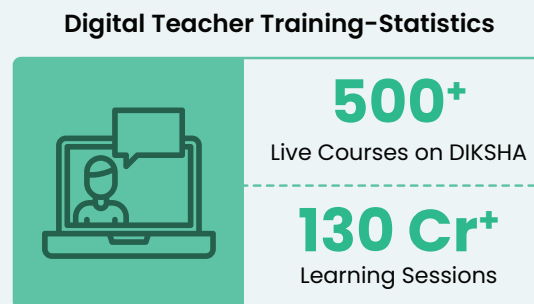
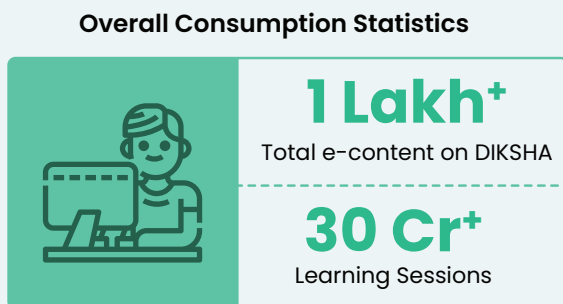
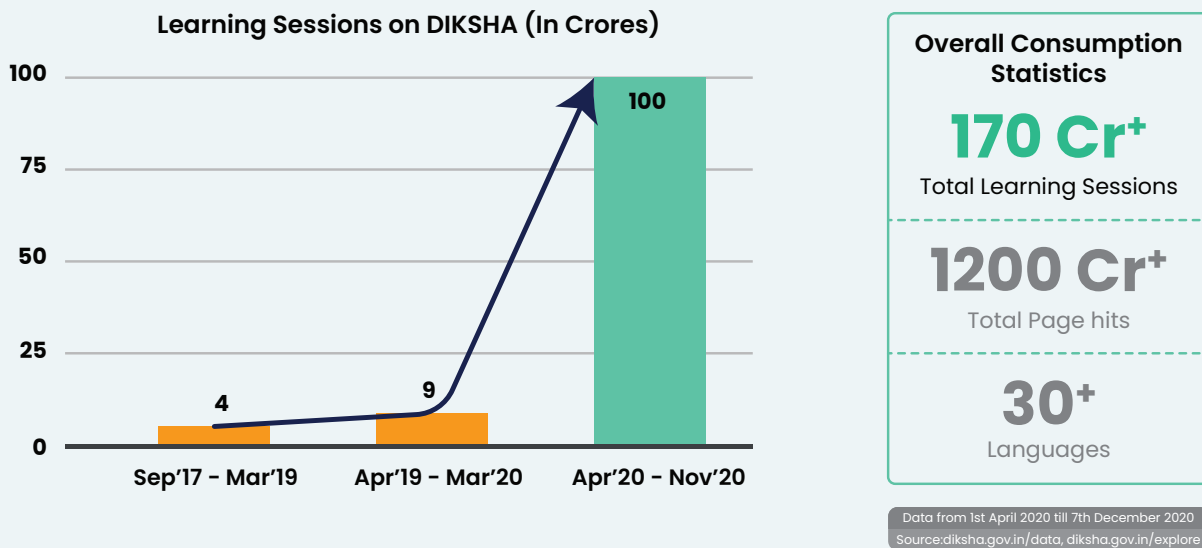


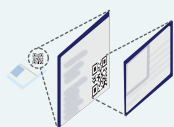
Figure 17 – DIKSHA Usage Statistics¹¹

¹⁰<https://diksha.gov.in/data/>

¹¹Link to webinar presentation to African region organised by World Bank
https://www.education.gov.in/sites/upload_files/mhrd/files/Secretary_DoSEL_Presentation_World_Bank_Webinar.pdf

DIKSHA is a flexible and evolving platform, with the below-mentioned diverse set of solutions, developed and that will continue to expand, based on the aggregated needs of the various states/UTs.

1. The Energised textbook solution allows educational boards to achieve that by enabling just-in-time access to digital content through QR codes printed in textbooks. This solution enables 18 crore+ students and 70 lakh+ teachers to leverage technology in the same way as a select few have been able to do so far.
2. Digital Teacher Training courses allow roll out of structured training programmes targeted to build capability or enhance specific knowledge and skills for teachers. As of January 2021 over 30 lakh teachers were digitally trained with the help of such courses on DIKSHA.
3. The periodic rollout of quizzes to provide an interactive format for joyful learning and promote healthy competition



Energised Textbook (ETB)

Physical Textbooks to “Phygital” Textbooks



Content Sourcing

Allowing individuals & organisations to contribute e-learning resources



Digital Teacher Training

A nationwide capacity building programme for “Improving Quality of School Education through Integrated Teacher Training”



PM eVidya

Aims to unify all efforts related to digital/online/on-air education to enable equitable multi-mode access to education










National Quizzes

Interactive & competitive learning

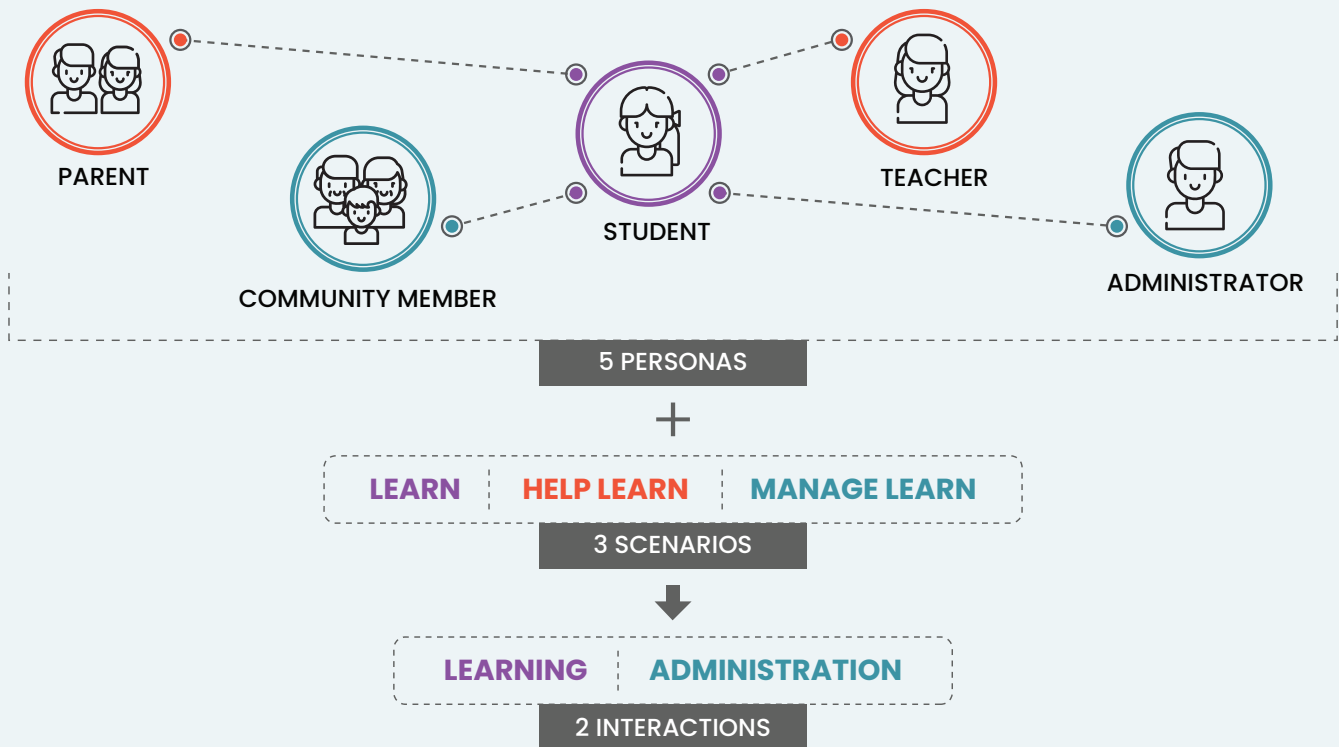
Figure 18 – Programmes Initiated on/with the Help of DIKSHA

4. DIKSHA’s technology architecture provides for a variety of content types suitable for teachers and students and their diverse teaching and learning needs. Examples of supported content types include videos that help teachers explain and learner’s learn, videos that clarify concepts; practice content for learners (e.g quizzes/questions); assessment content that help assess the learning for the benefit of teachers and students (e.g question bank and assessment tools); sample question papers for exam preparation; interactive content for an immersive experience to enhance learning; creative and critical thinking questions; lesson plans; micro-courses; curiosity questions for use in the class; among others.
5. DIKSHA supports a variety of types and formats of interactive content including HTML, ECML, videos, H5P, PDFs, MP4 and other formats.
6. Moreover, DIKSHA has been highlighted as an integral part of NEP 2020 providing multiple provisions for inculcating and promoting digital learning solutions. The key objectives of NEP 2020 are as follows:

	Objective	DIKSHA Status and Roadmap
	<p>Content creation, digital repository, and dissemination</p> <ol style="list-style-type: none"> 1. Coursework, Learning Games & Simulations, Item Banks, Teacher Professional Development, Virtual Labs 2. Augmented Reality and Virtual Reality apps 3. Gamification of Indian art and culture 	<ul style="list-style-type: none"> • VidyaDaan 2.0 has been successfully implemented by central organisations and States/UTs wherein 30K content was approved and published on DIKSHA • VidyaDaan 3.0 is being planned for receiving a variety of content with coordinated and orchestrated efforts of the ecosystem partners
	<p>Addressing the digital divide and equity</p> <ol style="list-style-type: none"> 1. Use of television, radio, and community radio; 2. Removing language barriers - Content in all Indian languages 3. e-content for disabled students 	<ul style="list-style-type: none"> • Coherence Strategy - NCERT and multiple other states are providing inclusive and equitable access to digital content on TV, Radio and DIKSHA to ensure coherence • More than 1.4 lakh content is available in 30+ languages
	<p>Training of teachers</p> <ol style="list-style-type: none"> 1. ICT integrated pedagogy 2. How to become high-quality online content creators themselves 	<ul style="list-style-type: none"> • 26+ states have rolled out NISHTHA trainings • Over 30 lakh teachers have been trained with the help of these courses on DIKSHA • NCERT and States are working to develop modular byte size content for providing high quality ICT integrated capacity building courses for teachers
	<p>Promoting digital learning</p> <ol style="list-style-type: none"> 1. Through different effective models of blended learning 	<ul style="list-style-type: none"> • Experiment for extending schooling by enabling teaching, learning and progress monitoring on DIKSHA has been initiated • Based on the feedback of the experiment/pilots, the solution will be rolled out for scale
	<p>Laying down standards</p> <ol style="list-style-type: none"> 1. Content 2. Technology 3. Pedagogy for online/digital teaching-learning 4. Guidelines for e-learning by States, Boards, schools. 	<ul style="list-style-type: none"> • Policies for developing e-learning content, framework, design principles and many other toolkits have been developed and are in process to ensure easier structured implementation • Guidelines for partnering with CSR, philanthropic organisations and other third party content providers is under progress and will be shared with all the States/UTs for easier onboarding of content providers • NCERT is also working on developing structured content review process and guidelines
	<p>Mathematical and computational thinking</p> <ol style="list-style-type: none"> 1. Starting with the foundational stage itself, through use of puzzles/games 2. Activities involving coding will be introduced in the Middle Stage. 	<ul style="list-style-type: none"> • Digital content catering to foundational learning and numeracy is being developed under National FLN Mission • Additionally, States are also putting efforts towards creating FLN content in alignment with the objectives of NEP 2020 • Content in the form of comics/puzzles/games is being developed by identified pedagogical experts from organisations and content partners

	<p>Other special areas for online learning</p> <ol style="list-style-type: none"> 1. Vocational courses 2. Teaching of languages, and knowledge of India 3. Rich e-content for learners with special needs, differently abled, gifted children, open school, adult education, e-libraries, virtual/e-museums, etc. 	<ul style="list-style-type: none"> • NIOS has on-boarded digital content for learners of open schooling ecosystem • NCERT and ISLRTC (Indian Sign Language Research & Training Centre) are working together to make education accessible for hearing impaired children in Indian Sign Language. • Audio books and podcasts are being uploaded on DIKSHA to cater to visually impaired children • Efforts are in progress to on-board courses focusing on open schooling and vocational training
	<p>Foundational learning</p>	<ul style="list-style-type: none"> • Content specially targeted towards early learners including assessment tools for assessing foundational learning achievements is being developed • Courses for capacity building of teachers and administrators to help achieve foundational learning mission goals is being developed
	<p>Energised Administration</p>	<ul style="list-style-type: none"> • Set of tools and processes that work well together is being piloted to be of help for administrators. Tools, process are being co-created and piloted with champion states and are likely to be deployed for use by all States and UTs. Energised administration aims to bring power of data and analytics to help efficient decision making and ease the efforts of teachers who help in implementing various learning and welfare objectives • These tools bring capabilities such as online surveys, project management, data analytics and visualisation capabilities especially of learning outcome achievements, tools that help convert physical assessment to digital, to speed up digitisation and decision making at scale
	<p>Energised schooling</p>	<p>Energised schooling, similar to energised administration, brings together various tools and resources well packaged to make learning and teaching efficient and fun. Energised schooling combines solutions already deployed at scale in the country, and aims to bring further efficiency to interactions of learning and teaching, for students, teachers and boards. These solutions and capabilities packaged together help users leverage them in a coherent fashion. These encompass:</p> <ul style="list-style-type: none"> • Efficient learning interaction for students by making high quality relevant learning resources easily accessible via energised textbooks. The media and resources are available for any-time, anywhere offline and online use across various consumption interfaces • Leveraging question bank capability and revision capabilities to bring high quality questions, answers to use of students • Teacher resources that help teachers to teach better by giving them access to highly curated and easy to use resources that they can leverage on demand • Resources to help Teachers to develop professionally and build capacity through online courses resulting in digital credentials

The implementation plan and priorities of NDEAR will follow the framework stated in the scope of NDEAR – namely the 5 personas and cater to 3 scenarios and 2 important interactions.



This implementation section lays down the following:

- **Activities** that will need to be undertaken in the initial 6 months; and
- **Projects** that may be taken up by the education ecosystem and the digital ecosystem to serve the needs of students, teachers, parents, administrators and the community.

The activities and projects will be taken up in a phased manner following the Building Blocks and Ecosystem approach of NDEAR.

Phases	Priorities	Timelines
Phase - 1	<ul style="list-style-type: none"> • Setting up of PMU, Project Steering Committee • Prioritise core set of foundational projects which have high usability and impact. Foundational projects will help develop core NDEAR building blocks which are leveraged by subsequent projects. 	0-6 months
Phase - 2	<ul style="list-style-type: none"> • Projects that provide impetus to NEP 2020 and FLN mission implementations leveraging projects from Phase-1 	6 months - 18 months
Phase - 3	<ul style="list-style-type: none"> • Projects that amplify efficiency and outcomes building off projects in Phase-1 and 2. 	18-months - 36months

1. Project Development Methodology

Each project could follow the methodology of 'Experiment - Pilot - Scale' and 'co-creation' which are detailed below.

S.N.	Method	Brief
1	Co-creation	Projects are evolved through co-creation with interested states which help prevent top-down thinking and envisaged and developed through equal participation. Co-creation must also involve ecosystem partners who will contribute to develop tools, specifications or use in the field for the benefit of the 5 personas.
2	'Experiment - Pilot - Scale'	As projects are evolved with the ecosystem to serve the needs of the personas. What better way to discover the needs than through experimentation and evolving the solutions, with the help of the ecosystem, through constant iterative developments? After the project is known to work as a large scale pilot in few early adopter states, the project is made available for scaling by the rest of the States/UT/central institutions.

2. Activities to be implemented within 6 months of NDEAR coming into effect

- a. Set up of NDEAR Project Management Unit (PMU) and Project Steering Committee (PSC), as envisaged to initiate the various projects and activities in a phased manner.

An initial list of projects to be taken up by the education and digital ecosystem are mentioned in the section below.

- b. Develop of Prioritisation and Implementation Strategy - PMU and PSC to list and prioritise the areas of implementation, define roadmap, milestones and granular implementation Strategy of NDEAR.
- c. Define further the specifications of the building blocks and identify existing core, common, reference and other building blocks.
- d. Support the design, development & implementation of core, common and reference building blocks, which would include preparing requirements and implementation guidelines.
- e. Scan of the available product space to identify those which can act as reference solutions or fulfil one or more functional requirements envisaged in NDEAR.
- f. Set up standards for establishment and management of registries which will be a single source of truth.
- g. Build reference applications for registries for students, teachers, credentials and schools.
- h. Develop standards, specifications and policies in the areas of open data, privacy and protection of data of individuals (particularly children).
- i. Ensure a shared understanding of the vision of NDEAR, orchestrate adoption of NDEAR and energise and catalyse the education and digital ecosystem to develop solutions and tools with the NDEAR approach and building blocks.
- j. Engage the education and digital ecosystem through events, hackathons, innovations fests and other such outreach, engagement and development programmes.

3. Initial List of Projects

A list of Projects that could be considered to be taken up in Phase 1, 2 and 3 are mentioned below. As open-source building blocks and co-created with champion states and offered by the education and digital ecosystem (MoE, MeitY, NCERT, CBSE, NIC (Centre and State), State/UT education departments, non-profit and private sector) complying with NDEAR principles – these projects are up for adoption by States and UTs, Central and State institutions for bringing efficiency to learning and administration interactions, across the 5 personas. The set of projects are classified as those that help administrative and learning interactions.

#	Administrative Projects	Brief notes
1	Teacher Registry	School, Teacher, and Student registries are core registries envisaged in the NDEAR.
2	School Registry	Federated Registries are essential first generation building blocks that make it possible for identities to be easily accessible by other building blocks and usable through “registry-as-a-service with open APIs”.
3	Student Registry	
4	Learning Outcome Directory	Publishing a common and open Learning Outcome Directory is an essential building block to achieve learning outcomes. It will contain the minimum learning standards, especially for the foundational years, as mandated by the NEP 2020 and the FLN Mission
5	Other important registries including – education boards, examination boards and other institutions related to the school education sector.	The next set of registries that need to be built are those required by state boards and examination boards to provide the strong foundation needed for operating schooling administration.
6	Online Tests/ exams, results, certificate services	<p>Support various types of assessments</p> <p>Online tests provide assessment services by leveraging identity, learning building blocks.</p> <p>Results portal services provide online access to all results.</p> <p>Results lead to certificates, which are stored and accessed via depositories.</p> <p>Certificates provide both permanence and easy access for the future.</p> <p>All awards and certificates will be issued as machine readable, verifiable documents with print option as per common schema standards.</p>
7	Assessment Tools and Analytics Services	Schooling generates a lot of learning assessment in physical form. A tool that helps convert physical to digital assessment data would help administrators to generate accurate and reliable data in real time, without causing significant time loss for teachers, who most often digitise these reports. Real time data, combined with the power of data analytic tools, aims to provide actionable insights for teachers and rest of the personas to improve the learning for teachers. This project also leverages identity services and learning services to deliver effective insights.

8	Learning Outcome Visualiser and Reporting Tools	Student outcome visualiser aims to help administrators to get accurate, real-time information of curriculum achievement, learning outcome achievement, at the most granular level, leveraging learning, data & analytics, identity building blocks, to help make important decisions to improve learning achievements in the country.
9	Education Credentialing Infra and Depository Services	Store and provide on-demand access to important personal records, including academic certificates, Holistic Report Card of students, training certificates of teachers, transfer certificates, among others. With the help of a strong depository service, combined with DigiLocker capability, States/UT/Central Institutions could offer reliable long term credentialing services to various other services.
10	School MIS/ERP in a box - Student Admission, Management, Attendance services	These services are meant to be used for building school management solutions. These include admissions, attendance, feedback, event management, community engagement, virtual PTA meetings, etc. These services address various aspects of personnel management, payroll, appointment, transfers, pension, service books/records management, manage payments, library management etc.
11	Command & Control Center (CCC) in a box	A Command and Control center and related processes and tools help administrators of the school board to establish a single real-time analytics-powered decision management process which could greatly enhance the efficacy of administration. CCC in a box leverages services of all NDEAR building blocks and serves to energise administration.
12	School affiliation services in a box	This would be developed as "services in a box" for use by States and by Education Boards to manage affiliation of schools under them. It addresses school affiliations, approvals, audits, inspections, recognition, school score cards, monitoring, and other feedback/grievances.
13	Awards and Recognition services in a box	These can be used to address the workflows, rules, and transaction capabilities for Centre, States, Boards, and ecosystem partners (an NGO could also use award services if they wish to) and schools to issue awards, recognition etc. for teachers, students, and other users.
14	Scholarship Services in a box	Scholarship service in a box addresses the workflows, rules, and transaction capabilities for Centre, States, Boards, and ecosystem partners (a company could also provide scholarship via CSR if they wish to) to provide scholarships for teachers and students.
15	Smart School Specifications and Reference Implementation	To enable wider deployment of smart schools; evolving a specification and implementing among reference schools with an ecosystem of solutions.
16	SMS/Email/IVR/Audio, Video Conferencing/Messaging Services	Provides configurable messaging services as a reference that can be leveraged by States and central institutions for collaboration and messaging services. Population scale video and audio conference services help all collaborative interactions to happen without necessarily involving physical movement. This project would be especially relevant to continue learning in-spite of disruptions brought about by any future calamities (like the current pandemic).

17	Schemes & Programmes Services, Project Management tools	<p>Scheme management services shall address scheme planning, definition, rollout, funds disbursed, monitoring, auditing, and so on and shall be integrated with registries. Scheme management allows the Government to ensure unification across schemes, easier enrollment for beneficiaries, and efficient fund management. This set of services will help all personnel across Centre, State institutions to easily roll out schemes and programmes.</p> <p>Strong set of project management tools and services will help the administration team to manage various programmes, schemes with efficiency and effectiveness.</p>
18	Energised Administration in a box	<p>Packaged and known to work well together, this is a set of tools, services which could be deployed for the benefit of all administrative personas, to bring efficiency and efficacy for the most commonly performed tasks, to improve learning and related service delivery such as mid-day meals, and other benefits for all personas. This package helps simplify the adoption for all actors concerned.</p>

Learn and Help Learn interactions of NDEAR may be achieved by the following projects, these are illustrative in nature and there will likely be many more project ideas that States and UT's and the education ecosystem may choose to pursue leveraging NDEAR building blocks.

#	Learning Projects	Brief notes
1	Content Sourcing Tools	Content sourcing tools such as VidyaDaan and others enable the education ecosystem to seek necessary content based on needs and content gaps; and for the ecosystem to respond to the need by providing, creating, curating content. This set of tools help boards to crowd-source various categories of learning, teaching content from the ecosystem and help with the tasks of sourcing and curation.
2	Next generation energised textbooks, Energised Content	Energised textbooks are a solution that is already widely adopted by Indian students and teachers. Next generation energised textbooks seek to upgrade and integrate latest advances in technology and content standards to improvise the learning and teaching experience for students and teachers. Energised content working in tandem with energised textbook projects aims to bring capability, highly interactive and immersive experience to students/teachers by leveraging emerging technology and content standards for development.
3	Smart Labs for students	Leveraging learning building blocks of NDEAR, tools and content aims to provide a visual, interactive and immersive experience for students and teachers to understand and appreciate important concepts. These set of tools and content bring these experiences especially to students who may be deprived of functional lab experience to conduct hands-on experiments.
4	Learning tools and content for Children with Special Needs and the differently-abled/ atypical	Using NDEAR building blocks to identify and develop contextualised solutions for various learning needs of children with special needs, the atypical and for the differently abled - specific focus to ensure FLN for these communities of learners.

5	Tools for Foundational Literacy and Numeracy Assessment	<p>NDEAR compliant tools that help students, parents and teachers measure FLN achievements, would catalyse efforts to achieve minimum learning levels.</p> <p>These sets of projects form the strategic basis to help the country achieve foundational literacy and numeracy by leveraging most of the building blocks of NDEAR</p> <p>These work in conjunction with data-emit principles and with data visualisation and analytics tools to dish out desired insights necessary for improvement.</p>
6	Question Banks	<p>Development and creation of high quality question bank infrastructure that enables sourcing, categorisation and usage of high quality questions for different grades and needs - these can be used to develop assessments, practice materials and various other solutions. High quality questions are a true asset and an infra that allows for contextual usage would help avoid duplication of efforts. This would aid learners and teachers to achieve learning outcomes to set standards.</p>
7	Online Tests/Exams, Results, Certificate Services	<p>Supporting various types of assessments, online tests help to provide assessment services leveraging identity, learning building blocks. Results portal services aim to provide online access to all results. Results leading to certificates that are stored and accessed via depositories provide both permanence and easy way to access in future - All awards and certificates will be issued as machine readable, verifiable documents with print option as per common schema standards.</p>
8	Personalised Learning Assistant	<p>Leveraging the energised textbooks, energised content on DIKSHA, improvised question bank solution on DIKSHA (part of earning services building block) and identity building blocks, Personalised Learning Assistant solution aims to help students to learn at their own pace leveraging the power of AI/ML and extensive content and tools already available in the learning building block of NDEAR.</p>
9	Creation of OpenSource Language Translations, Speech/text, text/speech engine/API	<p>To enable wider use of technology in Indian languages, translation and speech/text applications can be leveraged to improve foundational literacy among young children.</p>
10	<i>Wordnet - bhasha dictionaries</i>	<p>Multilingual focus of NEP 2020 will need support with access to language tools of various kinds. The work done across the country on language and words and dictionaries can be built upon. Developing a solution for multilingual dictionaries, linked to levels of learning, would be hugely beneficial to further develop - tools, games, worksheets, practice materials and vocabulary development from early years up to professional level.</p>
11	Capacity building of teachers, administrators	<p>Anytime, anywhere access to courses and training provided by a wide ecosystem.</p>

12	Collaborative network of teachers	<p>An ecosystem solution developed using NDEAR building blocks to create a digital space for a collaborative network of teachers.</p> <p>The space should be open and free to enable teachers to join and participate by choice in communities of practice; seek expert assistance where they need it; connect with other teachers and learn and improve their skills and fulfil their requirements. A collaborative network of teachers and tools and processes around the same could serve as a network of mentors for teachers to support each other in their areas of growth.</p>
13	Energised Schooling in a box	<p>Set of optimised solutions designed for Boards to deploy for the benefit of teachers and students. It involves the collation of various solutions known to work well together and are maintained as such. This packaging helps students and teachers and the board administration to deploy it easily and regularly, for teaching and learning. Energised schooling in a box leverages NDEAR building blocks, existing solutions as well as improvising existing solutions to develop a powerful value proposition for adoption. It leverages learning, identity building blocks primarily, and builds off of existing solutions and APIs of DIKSHA.</p>
14	Video and Audio Conference Services	<p>Population scale video and audio conference services help all collaborative interactions to happen without necessarily involving physical movement. This project would be especially relevant to continue learning in-spite of disruptions brought about by future calamities (like the current COVID-19 pandemic).</p>



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Department of School Education and Literacy
Ministry of Education
Government of India

NDEAR