Sattva Knowledge Institute SKI primer

NATIONAL DIGITAL EDUCATION ARCHITECTURE (NDEAR)

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Acknowledgements

About the Authors

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EXECUTIVE SUMMARY

Background

While various measures have been taken to transform India's education landscape, significant challenges continue to plague the public education system such as high student dropout rate at the secondary level (15%). Nearly 5 crore elementary school students are below the required level of foundational literacy and numeracy; only about 45% of Class 5 students studying in government schools can read Class 2 level textbooks.

With the introduction of the National Education Policy 2020 and the development of edtech innovations, digitisation was recognised as a key lever to address the present challenges facing the Indian education system.

Overview of NDEAR

The government developed the National Digital Education Architecture (NDEAR), an architectural blueprint, that lays down a set of guiding principles and building blocks to enable the creation of digital technology-based applications pertaining to education.

Solution developers can leverage NDEAR's building blocks, that is, a set of reusable digital resources (such as open source software and APIs) to build digital platforms and technologies for education. These building blocks are categorised as core (built and managed as public goods that enable interoperability among all building blocks), common (offered as options for ecosystem to build alternative versions) and reference building blocks (accelerators offering only source code to be leveraged for rapidly building services).

NDEAR's architectural principles also guide the development and operation of building blocks and digital solutions to ensure transparency, scalability and interoperability among the technologies developed.

Under the NDEAR framework, a range of digital tools and technologies have been proposed or implemented. These not only aim to enhance students' learning, but also enable creation of efficient management systems for educational institutions, capacity building of teachers, and effective monitoring of students' progress.
For example, the DIKSHA app, a reference solution developed using NDEAR, offers a range of features, including textbooks made available digitally, online quizzes for practice, chat bots, and content creation tools for teachers. Other solutions proposed to be developed under the NDEAR framework include digital student attendance monitoring system, digital locker for educational credentials, and digital student report cards.

Use Cases

NDEAR has the potential to enhance students' learning experience by providing access to diverse study material including textbooks, videos and animations, made available digitally in English and various regional languages. It also speeds up the admission process for students by introducing a digital learning passbook, wherein educational credentials can be shared between institutions by providing consent on a click, negating the need for physical paperwork.

Digital tools improve teachers' productivity with respect to their teaching and administrative responsibilities. Digital solutions such as the Saral app save instructor time on checking, recording and assessing students' marks and learning levels. Additionally, NDEAR enables schools to digitally store institutional records (including data on attendance, dropouts and assessment), facilitating easier sharing of required data with government administration.

Governance and Implementation

The Ministry of Education has set up a Programme Management Unit for the immediate roll-out of NDEAR. Moving ahead, though, an autonomous body, the National Educational Technology Forum, is likely to be established to facilitate capacity building in education technology, and set standards for the content and pedagogy for digital education.

Challenges

While NDEAR appears, in principle, to solve some pressing challenges plaguing the education system, effective implementation is necessary for realising its full potential. Impediments to this include low internet penetration, sporadic digital infrastructure in rural areas, and low digital literacy among learners. Further, given that education is a state subject, the implementation of NDEAR across the country could be non-uniform.

BACKGROUND

Since the launch of the Unified Payments Interface (UPI), the government has explored similar digital public goods in other sectors; this primer takes a deeper look at the National Digital Education Architecture (NDEAR).

Background

- India has emerged as a pioneer in developing and deploying digital public goods at scale.
- It was one of the first developing countries to have a population-scale digital ID initiative, and has built digital payments infrastructure such as the UPI.
- Since the launch of the UPI in 2016, the government has looked to create similar digital public goods in a host of other areas such as education, digital lending, e-commerce, healthcare, livelihood and others.

Context

- This primer aims to provide an understanding of the National Digital Education Architecture (NDEAR).
- The objective of this primer is to:
  - Understand the underlying principles, use cases and governance of NDEAR;
  - Understand the grey areas NDEAR needs to address for effective implementation and
  - Build a case for NDEAR in the current education landscape.

Digital transformation has been recognised as imperative to address the challenges facing the public education system in India.

Challenges in the public education system in India...

15 crore
children and youth are out of the country's formal education system. (Ministry of Education 2021).

5 crore
elementary school students have not attained foundational literacy and numeracy. (Ministry of Education 2020).

44.2%
of Class 5 students studying in government schools can read Class 2 level textbooks. (ASER 2018).

14.6%
average dropouts at the secondary level nationally, with the dropout rate higher than the national average in 12 states. (Ministry of Education 2022).

60%
school children in India cannot access online learning opportunities, limiting the positive impact of emerging technologies in transforming education. (Azim Premji Foundation 2021).

...addressed through legislation and innovation

National Education Policy (2020)

Aims to achieve universal access to quality education and critical reforms in the education system, including establishment of

- National Mission on Foundational Literacy and Numeracy;
- National Education Technology Forum for schools and higher education and
- Dedicated institutes for assessments (such as PARAKH).

Technology solutions such as DIKSHA, SWAYAM, UDISE+

Digital innovations were introduced by non-profit organisations, private sector, and the government to serve the needs of learners and teachers.

- There also exist public sector-supported digital initiatives such as DIKSHA (Digital Infrastructure for Knowledge Sharing), SWAYAM and Unified District Information System for Education (UDISE+).

OVERVIEW OF NDEAR

NDEAR is an architectural blueprint that enables the creation and use of digital technology for interventions in education.

What is NDEAR?

- An **architectural blueprint** for digitisation of the educational system that aims to facilitate achieving the goals laid out in the National Education Policy 2020.
- Defines a set of principles, standards, guidelines and policies to strengthen the digital infrastructure for education.
- It follows the **National Open Digital Ecosystem (NODE) strategy.**
- The strategy aims to create interoperable 'Digital Commons' using open software, open Application Programming Interfaces (APIs), open standards, and open licenses.

What will it do?

NDEAR's technology framework allows the ecosystem to create physical or digital solutions and tools for skilling and education.

NDEAR will provide:

1. Specification and standards: Set of interoperable standards and specifications which allows interoperability and portability across all systems.

2. Microservices and APIs: Unbundled services available via APIs, which can be used by the ecosystem to build solutions to address the diversity and scale.

3. Reference Solutions:
Set of reference solutions and apps that can be used freely out of the box by students, teachers, parents, administrators, and community members.

Who are the stakeholders?

NDEAR enables various ecosystem actors to create solutions and assets.

Government agencies

Non-profit organisations

Private organisations

Who are the beneficiaries?

Solutions created using NDEAR will be used by various beneficiaries to enhance learning .

Learners

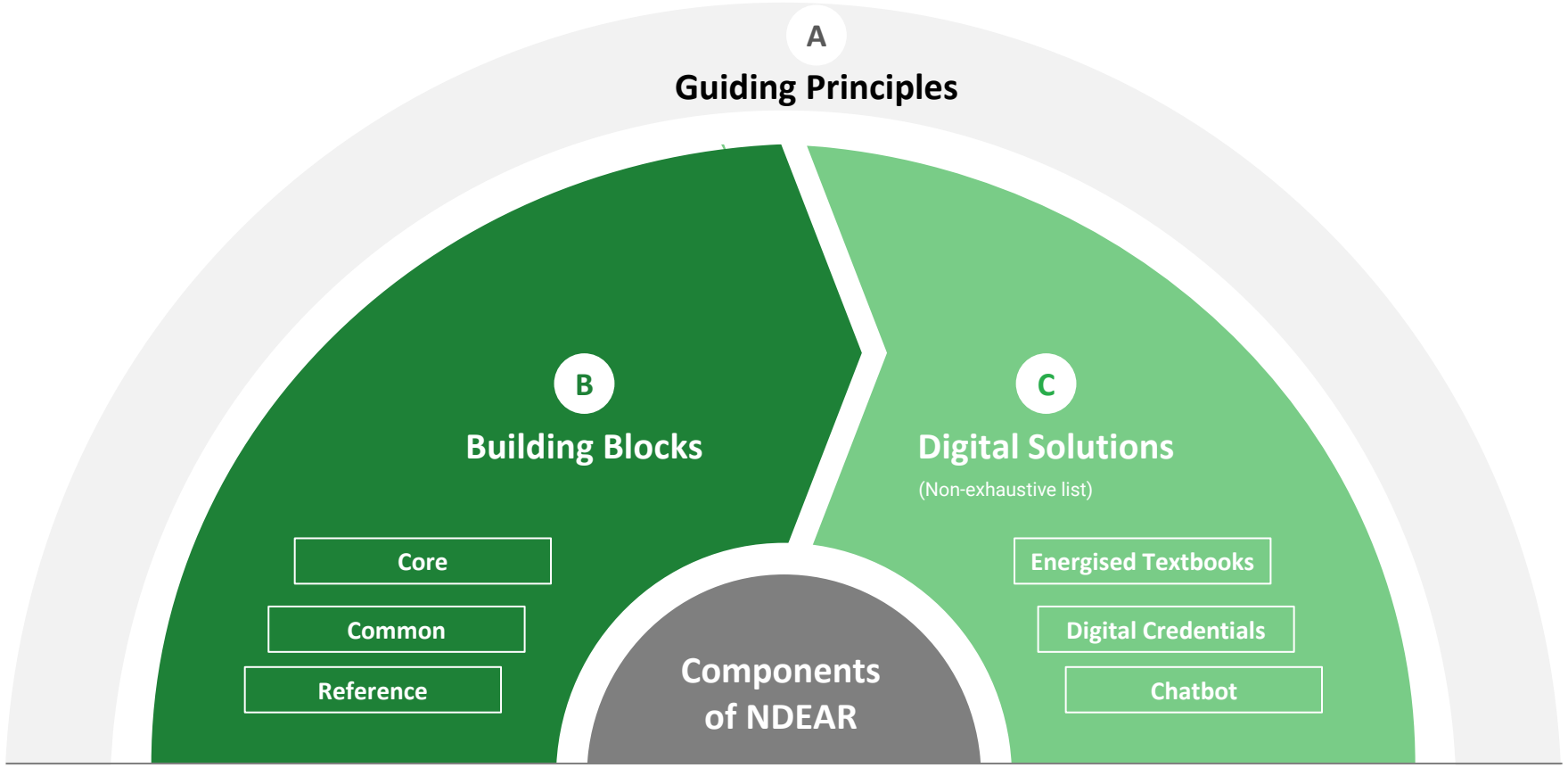
Parents

Administrators

Teachers

Community Members

NDEAR's building blocks are leveraged to create digital tools and solutions guided by its architectural principles.



Guiding principles

Common set of principles and approaches to be followed in building, using and reusing technology for education.

Building blocks

Set of generalised and reusable functional capabilities, micro-services, and interfaces, categorised as:

- **Core building blocks** built and managed as public goods that enable interoperability among all building blocks.
- **Common building blocks** built and offered as options for the ecosystem to build alternative versions.
- **Reference building blocks or** accelerators offering only "source code or data" to be leveraged for rapidly building services.

Digital Solutions

Solutions, including digital platforms and tools, that are developed using NDEAR building blocks.

A Guiding Principles

NDEAR's 12 principles ensure interoperability, transparency, scalability, security in digital solutions developed for education.

Adopt India Enterprise Architecture (IndEA) framework

The design of the building blocks of NDEAR to adopt and conform to IndEA by default.

Built on and as open-source, and using open standards

All services to be based on and built as open-source; open international and national standards to be adopted to ensure interoperability and portability.

Portable

To be designed for portability of data, certificates, credentials, documents and content based on open standards.

Scalable

All technology services and processes to be designed for operating at the intended scale through automation and distributed human processes.

Resilient

Services to be equipped with automated recoveries and adaptation; processes established as part of NDEAR to allow flexibility and re-adaptation to handle disruptions.

Interoperable via open APIs and standards

Design interoperability via open APIs and open standards to be ensured so solutions built by the ecosystem work in a unified manner.

Use of emerging technologies

NDEAR should be designed to leverage technological innovations as and when they become viable and useful to improve education.

Open data and observability via "data emit"

Open data to be made available as public good accessible by all for enhancing research and interventions in education, as per the National Data Sharing and Accessibility Policy.

Minimal, reusable, unbundled microservices

All services that are part of NDEAR to be designed in a generalised manner allowing solution builders to reuse and extend them across diverse contexts.

Security, privacy, trust, data empowerment by design

All solutions and services within NDEAR must adhere to appropriate data protection and privacy laws.

Registries and master codes as single source of truth

Decentralised electronic registries and master codes should be designed into the architecture via common APIs for interoperability and unification.

Evolvable

All NDEAR building blocks to be clearly versioned to be able to adapt and upgrade asynchronously and evolve along.

B Building Blocks

NDEAR comprises building blocks that can be used by various ecosystem players to develop relevant platforms, solutions and programmes.

A Building Block is a **reusable package of business or technological functionality.** The functionality can be reused in multiple use cases and solutions with marginal effort, thereby cutting down on design and development time. In substance, a building block may be comprised of data, application, or a set of interfaces.

Building blocks

Open Standards and NDEAR Portal
- Community-driven open standard protocols, specifications and knowledge
- Available as open source via NDEAR portal

Technology
- Locker and consent management
- Open artificial intelligence (AI) services
- Shared user experience (UX) services
- Language assets and services

Content
- Contribution and curation
- Taxonomy and tagging
- Language and translation
- Discovery and personalisation

Open Data and Analytics
- Open source geospatial software products

Federated Identities
- Students
- Teachers
- Educational institutions

Infrastructure
- Education network and cloud
- Messaging and video/audio conferencing
- Education Data Exchange
- Open school hardware

Learning
- Learn, Do and Practice, Sense and Assess
- Interaction and collaboration
- Credentialing and badging of skills
- Learning infrastructure, telemetry and analytics

Ecosystem Sandbox
- Rules, tools, policies, governance processes, certifications

Reference Data
- Master data or codes
- Directories
- Registries (school teachers, students etc)

Governance
- School affiliation
- Awards and recognition
- Examination, results, and certification
- Schemes, programmes, and scholarships

Administration
- Personnel and payroll
- Admissions, attendance and tests
- School management, mentoring and counselling

Reference Application
- Multi-channel, unified, coherent and accessible applications or solutions UX (mobile, web, TV, phone, radio, chat, voice)

B Building Blocks

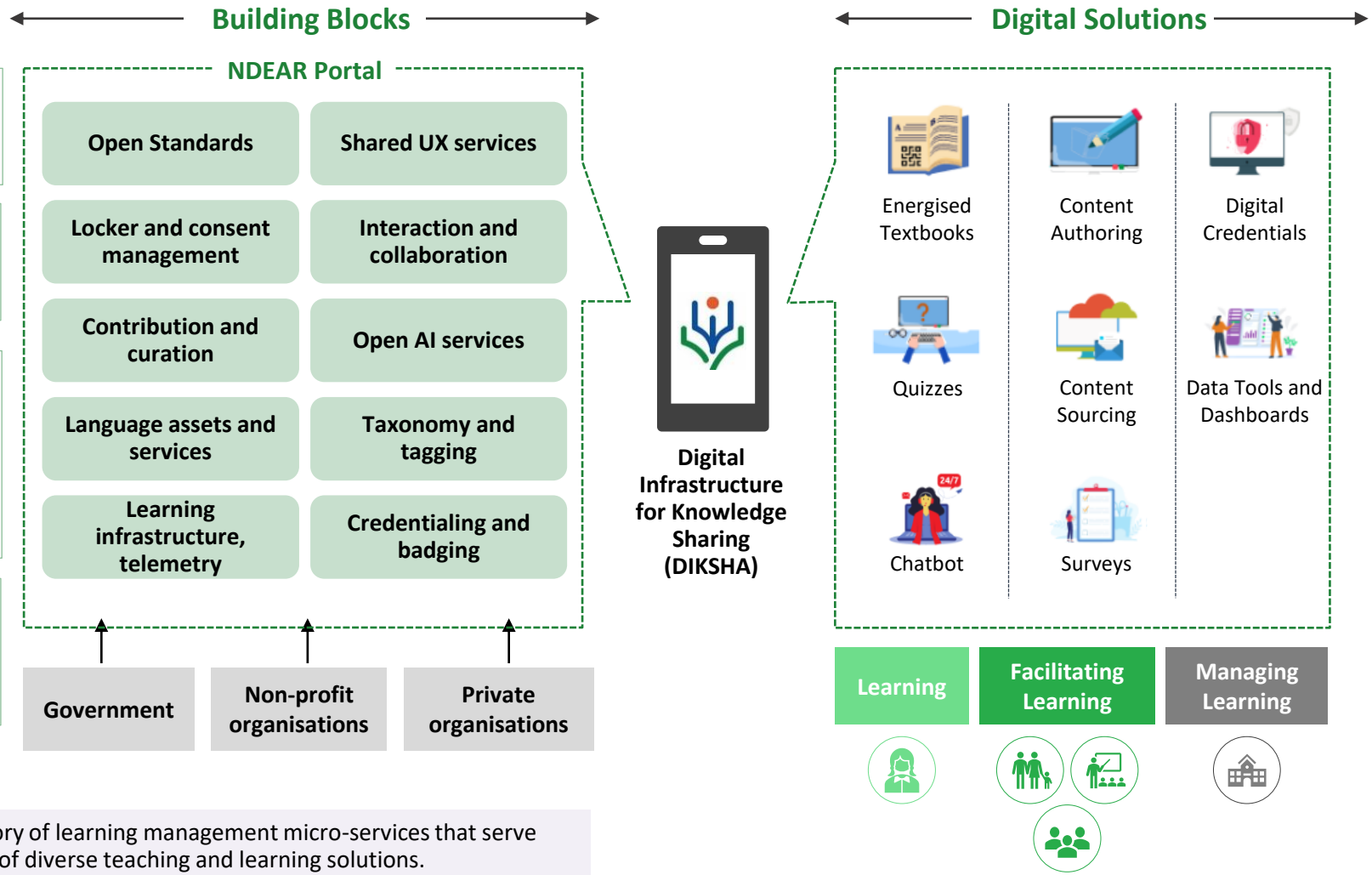
Example: NDEAR's building blocks were leveraged to create DIKSHA, a reference application that provides a range of solutions that digitises education, from learning to management.

Building blocks are made available to ecosystem players through NDEAR Portal, who may leverage these to develop digital solutions and tools for education

DIKSHA, a reference application developed using Sunbird's open-source technology and containing NDEAR building blocks, offers various capabilities.

For example, the use of NDEAR's language assets and services enabled the creation of energised textbooks (QR Code-incorporated physical textbooks that can be used to access digital content on DIKSHA portal by simply scanning the code) and quizzes made available to students in multiple languages.

Digital solutions available through DIKSHA may be used by learners, parents, teachers, community members, and administrators to assist in learning, facilitating and managing learning.



- Sunbird is an open-source repository of learning management micro-services that serve as building blocks for the creation of diverse teaching and learning solutions.
- Sunbird's open-source technology led to the creation of DIKSHA.

C Digital Solutions

Digital solutions developed by leveraging NDEAR will not only aid in enhancing students' learning, but will also enable the creation of an efficient management system for educational institutions.

NDEAR enables the creation of digital solutions (platforms, tools, services) across educational processes.

1 Learning

Includes digital platforms or tools that will directly aid **students** and enhance their learning capacity by:

- Improving access to resources and study materials;
- Facilitating planning and self-assessment of study progress and
- Enabling discussion and interaction in class.

2 Facilitating Learning

Includes solutions that will aid **teachers, parents and community members** in ensuring the creation and maintenance of a suitable learning environment by:

- Enabling teachers and relevant community members create learning resources;
- Enabling teachers and parents to monitor students' progress and
- Enhancing interaction between teachers and parents.

3 Managing Learning

Includes digital tools and platforms that will assist **educational institutions** in ensuring smooth functioning and administration of their institution by:

- Enabling quick and easy sharing of digitally verifiable educational credentials for interoperability across institutions and
- Addressing teaching gaps and strengthening teaching infrastructure.

C Digital Solutions

Students benefit from easier access to study material, enabling self-assessment and greater interaction with teachers.

1 Learning

Solutions developed using NDEAR building blocks help students enhance their learning capacity.

	Increasing access to learning resources	Enabling efficient planning and self-assessment of study progress	Enhancing interaction between students and teachers
Implemented	• **Energised textbooks:** Relevant digital learning resources linked to textbooks • **Digital Courses:** Structured skill-building programmes for students	• **Digital Projects:** Digital solutions helping users plan learning tasks in a set amount of time	• **Collaboration tools:** Services enabling discussion and interaction between students and teachers on key topics • **Multi-Channel Chatbot:** Personalised chatbot across channels such as WhatsApp, Telegram and SMS
Proposed	• **Customisable mobile application for teaching and learning:** A reference mobile application to access digital learning content • **Doubt solving via chatbot:** Doubt solving tool that uses video solutions	• **Student/Teacher-centric Digital Locker for Educational Credentials:** All inclusive digital learner wallet or passbook for learners • **Shiksha capability for student assessments:** Tools enhancing assessment functionalities for better understanding of student learning outcomes • **Digital Student Report Cards:** Dynamic report cards made available to students	• **LIVE classes and exemplar content linked to Energised Textbooks:** Tools enabling two-way classroom interaction online

Building Blocks

Open Standards	Electronic Registries	Open School Hardware	Shared UX Services	Taxonomy and Tagging	Open Data
Digital IDs for Students	Messaging and Video/Audio Conferencing	Open AI Services	Language Assets and Services	Learn, Do and Practice, Sense and Assess	Learning Infrastructure, Telemetry and Data Analytics

(Non-exhaustive list)

C Digital Solutions

Community and teachers leverage digital tools to create relevant study materials; surveys and report cards made available digitally enable easier monitoring of students' progress

2 Facilitating Learning

Solutions developed using NDEAR building blocks help teachers and parents facilitate learning.

	Enabling teachers and community members to develop learning resources	Enable teachers and parents to monitor students' progress	Enhancing interaction between Teachers and parents
Implemented	• **Content Authoring:** Digital solutions enabling teachers and other authors to create interactive good-quality digital content • **VidyaDaan:** Enables individuals and organisations to contribute e-learning resources to be used by students and teachers	• **Saral App:** Data and analytical tools to identify students falling behind on learning levels with easy uploading of students' assessment data by simply taking a picture of marks • **Digital Surveys:** Tools to collect feedback from students in digital form	• **Collaboration tools:** Services enabling discussion and interaction between teachers and parents celebrating successes, and addressing any gaps in students' learning • **Multi-channel Chatbot:** Personalised chatbot across channels such as WhatsApp, Telegram and SMS facilitating greater interaction between teachers and parents
Proposed	• **Content contribution and volunteering capability:** Tools facilitating volunteers' contribution to development of study content	• **Digital Student Report Cards:** Dynamic report cards made available digitally for easier monitoring of students' learning levels, without having to physically collect report cards	

Building Blocks

Open Standards	Electronic Registries	Locker and Consent Management	Shared UX Services	Master Data or Codes	Messaging and Video / Audio Conferencing
Open Data	Digital IDs for teachers	Open AI Services	Education Network and Cloud Services	Directories	Language and Translation

(Non-exhaustive list)

C Digital Solutions

Educational administrators leverage attendance monitoring systems, digital surveys and digital report cards to strengthen teaching infrastructure; digital credentials enable interoperability.

3 Managing Learning

Solutions developed using NDEAR building blocks help educational institutions manage learning.

	Strengthening teaching infrastructure	Enabling interoperability between educational institutions and government authorities
Implemented	• **Digital Surveys:** Tools to collect feedback or information about different educational institutions in digital form	• **Digital Credentials:** Enables generation and sharing of digitally verifiable credentials using open credentialing standards, making them portable and interoperable.
Proposed	• **Student Attendance Monitoring System:** Tools to monitor student attendance and plan interventions accordingly • **Digital Student Report Cards:** Student report card to understand learning outcomes and implement localised and contextualised initiatives accordingly	• **Students/teacher-centric digital locker for educational credentials:** Enables all-inclusive digital learners' passbook for educational credentials.

Building Blocks

Open Standards	**Electronic Registries**	**Education Data Exchange**	**Locker and Consent Management**	**Education Network and Cloud Services**
Open Data	**Digital IDs for Educational Institutions**	**School Affiliation Services**	**Personnel and Payroll**	**Directories**

(Non-exhaustive list)

USE CASES

NDEAR enables Khushi, a middle school student to leverage online learning materials in her native language to prepare for her exam; Ashish, an 11th grade student seamlessly transitions between schools.

Profiles		Current Landscape	Opportunities with NDEAR
 Name: **Khushi** Age: **12** | Gender: **Female** Location: **Ahmedabad, Gujarat** Grade: **Class 7 student at government school** Parents: **Both parents are daily wage workers**	**Access to diverse study material**	• Only has the option to study from her NCERT textbook to prepare for exams	• Downloads learning materials and games for practice by scanning QR codes in her energised textbook; accesses videos through virtual labs on DIKSHA
	Access content in regional languages	• Faces difficulty grasping parts of syllabus and does not receive help from parents, as she is a first-generation English learner	• Able to better grasp concepts as study materials are in native language (Gujarati)
	Opportunities for practice	• Practises for exams by attempting limited practice questions available in her textbook	• Tests conceptual understanding by attempting assessments available through QR codes and DIKSHA app
	Ease in monitoring study progress	• Parents are unable to take out time from work to meet her teacher to understand her learning level or challenges he faces	• Parents view holistic Digital Report Card to monitor progress
 Name: **Ashish** Age: **16** | Gender: **Male** Location: **Chennai, Tamil Nadu** Grade: **Class 11 student relocating from Madurai to Chennai, and must take admission in a new school**	**Faster admission process**	• Physically visits preferred school to complete paperwork, fill out admission forms, and waits for documents to be processed	• Changes schools seamlessly by linking learning passbook with the new school's admission system without having to fill additional forms
	Digital sharing of documents	• Forced to travel back to Madurai to collect his transcripts and documents from previous school	• One-click request to old school to transfer relevant documents and transcripts to new school, through his digital locker that stores educational credentials
	Access to scholarships and grants	• Searches different websites to prepare a list of grants and scholarships offered by a range of organisations and institutes	• Applies for various scholarships and financial grants through the digital learning passbook

Digital tools save time on administrative tasks enabling Rachna, a teacher to focus on her teaching responsibilities; she improves her teaching methods and monitors students' progress digitally.

Profile

Name: **Rachna**

Age: **33** | Gender: **Female**

Location: **Delhi**

Profession: **Middle school mathematics teacher at a government school**

Rachna also has to perform a range of administrative tasks in the school, which sometimes divert her from teaching.

		Current Landscape	Opportunities with NDEAR
Teaching tasks	**Access to teacher training content**	• Faces difficulty finding accurate resources to learn about interactive teaching methods that would help students learn better	• Utilises online support through digital courses and Teacher Energized Reference Manual (TERM) to learn new and engaging teaching methods
	Easy analysis of learning levels	• Regularly updates students' assessment data after every test to understand their progress, which is time-consuming	• Saral app saves time on checking, recording and assessing learning levels of students using AI tools, allowing her to help students who are falling behind
Administrative tasks	**Address high dropouts and low attendance**	• Maintaining attendance and dropout records may restrict administration's ability to identify attendance issues due to manual errors	• Using digital student attendance monitoring system for accurate recording and helping school administration take appropriate measures
	Assistance to government administration	• Reporting and sharing assessment data with district administration may result in inaccurate judgement of school's performance due to manual errors	• Digitally shares school's accurate assessment data available as electronic registries with district administration, which helps them develop policies and schemes accordingly

GOVERNANCE AND IMPLEMENTATION

The Ministry of Education (Government of India,) focused on the immediate rollout of NDEAR through a Programme Management Unit; the National Educational Technology Forum will take up this role in future.

NDEAR Programme Management Unit (PMU)

As a larger institutional framework will take time to fully fructify, the Ministry of Education set up a Programme Management Unit (PMU) for the immediate rollout of NDEAR.

- **Role:** To develop an implementation strategy, identification and prioritisation of work, budgetary estimation, design, and monitoring.
- **Components:** The PMU will comprise of a Project Steering Committee (PSC) (with representatives from Government and non-government or private organisations, and experts in the field of education and technology) to provide, review and monitor strategic direction and policy guidance to the PMU and other stakeholders.
- **Governance:** The PMU will initially work directly under the Ministry of Education, until the NDEAR institutional setup is ready.

National Educational Technology Forum (NETF)

Recommended institutional framework under NEP 2020:

The National Educational Technology Forum (NETF) will be set up in future as an autonomous body, to facilitate decision making on technology in learning, assessment, planning, administration for schools and higher education.

NETF aims to

- Build intellectual and institutional capacities in education technology;
- Lay down standards of content, technology, and pedagogy for online/digital teaching-learning;
- Support technological interventions for teachers' development, streamlining educational planning and management (including admissions, attendance, and assessments processes).

The PMU will set up data policies and registries, create reference solutions, undertake outreach activities, and support knowledge management to ensure seamless implementation of NDEAR.

PMU's role in operationalising NDEAR across the country

Prioritisation and implementation strategy building

- Prioritise Samagra Shiksha, foundational literacy and numeracy, and early childhood education in implementation.
- Support the preparation of a detailed action plan and project fund requirements.

Building blocks

- Define specifications of building blocks and identify existing core, common, reference building blocks.
- Support the design, development and implementation by preparing requirements and implementation guidelines.

Registries

- Set up standards for establishment and management of registries.
- Build reference applications for registries for students, teachers, credentials and schools.

Data policies

- Set up standards, specifications and policies for open data, privacy and protection of data of individuals (particularly children).

Reference solutions

- Create reference solutions, wherever required for the selected areas and projects taken up.

Requirement and integration management

- Suggest business process improvements, test feasibility and finalise requirements.
- Identify, define, combine, unify and coordinate the required processes and activities.

Programme and project management

- Support overall management of NDEAR and implementation of various projects/solutions under NDEAR.

Procurement, contract and vendor management

- Procurement of service providers for NDEAR building blocks and reference solutions.
- Support organisational planning, staff acquisition and team development.

Relationship and communications management

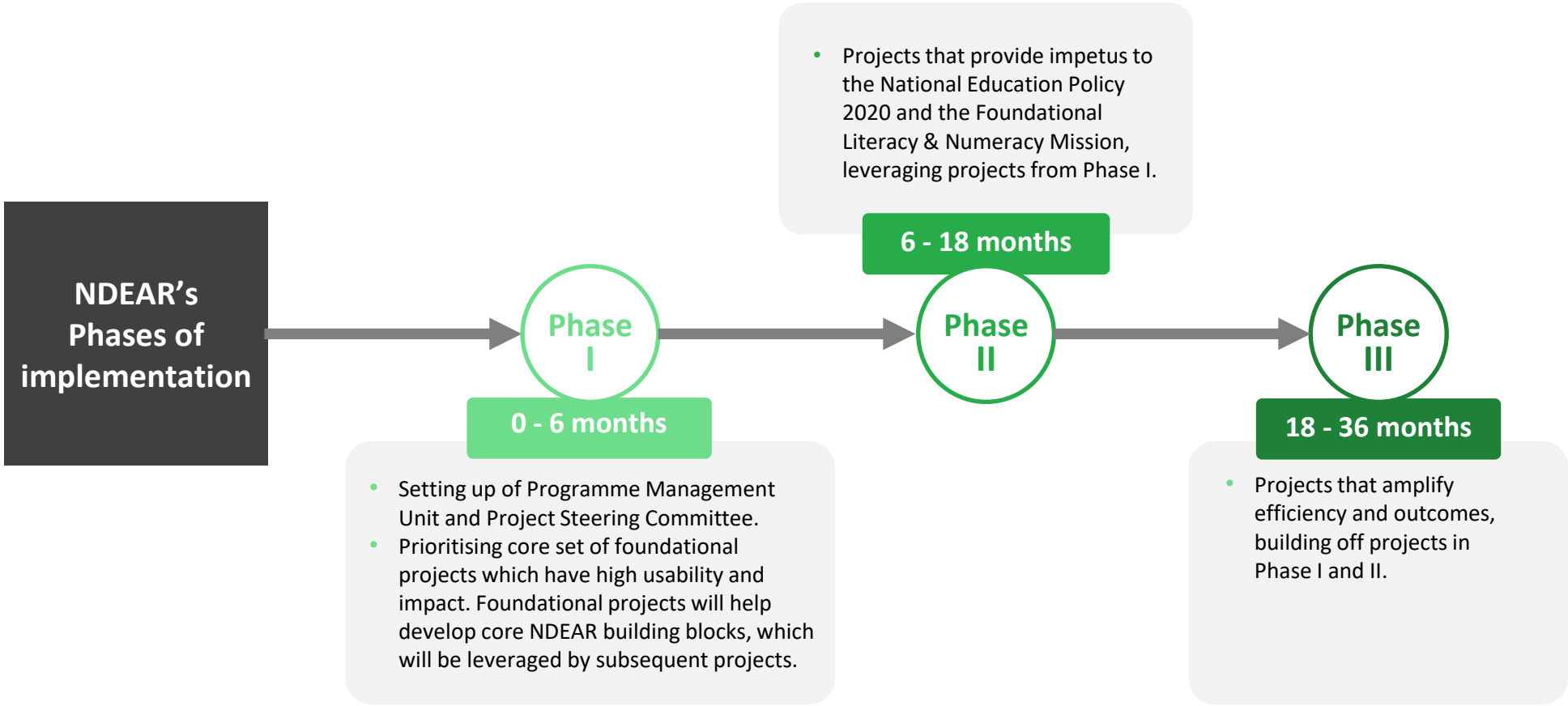
- Ensure shared understanding of NDEAR's vision and implications among all key stakeholders.
- Engage ecosystem through outreach and development programmes such as hackathons, innovations and fests.

Knowledge management

- Support creation of a centrally managed repository for all information gathered and produced over the lifetime of the project.

NDEAR will be implemented in three phases.

The rollout of foundational projects and setting up of governing authorities will be prioritised, followed by measures to amplify efficiency by leveraging foundational projects.



CHALLENGES FOR NDEAR

Low internet penetration, inefficient digital infrastructure, lack of incentive for private players to build solutions, and non-uniform adoption across states impede the successful implementation of NDEAR.

Challenges for NDEAR

Structural Challenges

Lack of incentive for private players	Less incentive (such as monetary benefits) for private players to develop a solution ecosystem by leveraging NDEAR's public infrastructure.
Inadequate regulation of NDEAR's consent mechanism	While NDEAR aims to use a consent-oriented framework, the consent mechanism requires greater regulation to secure data rights of children, a key beneficiary group.
Need for developing an array of use cases	Need to develop a larger range of use cases outlining digital tools and applications to be developed, so that developers can conceptualise solutions better.

Implementation Challenges

Sporadic digital infrastructure and capacity in schools and rural areas	NDEARs success depends on reliable digital infrastructure (such as access to computers, phones, electricity, and internet) and related capacity building among students - both of which are currently at a suboptimal level.
Risk of non-uniform adoption of NDEAR across states	Since education is a state subject, effective implementation across the country would require states to be onboarded with a clear value proposition for NDEAR.
Limited time and capacity for teachers to drive digital learning	Administrative duties take up nearly 50% of teachers' time, leaving less time for required capacity building to transition to digital education (Davis & Singh 2019).

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