IMPLEMENTING PERSONALISED ADAPTIVE LEARNING AT SCHOOLS

A guidance Note for States

22nd May 2018

Draft for discussion only

MHRD | Department of School Education & Literacy
Ministry of Human Resource Development
Government of India

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LIST OF ABBREVIATIONS USED

Acronym	Full-form
AI	Artificial Intelligence
API	Application Programming Interface
ASER	Annual Status of Education Report
CAL	Computer Assisted Learning
CC-BY	Creative Commons By Attribution
CC-BY-SA	Creative Commons BY Attribution and Share-Alike
ChiPS	Chhattisgarh Infotech Promotion Society
CIET	Central Institute of Educational Technology
CRC	Cluster Resource Centre
EdTech	Education Technology
EoI	Expression of Interest
ERP	Enterprise Resource Planning
GER	Gross Enrollment Ratio
HM	Head Master
ICT	Information and Communication Technology
IP	Intellectual Property
KPI	Key Performance Indicator
MEL	Monitoring, Evaluation and Learning
MHRD	Ministry of Human Resource Development
MIS	Management Information Systems
MOOC	Massive Open Online Courses

NAS	National Achievement Survey
NCERT	National Council of Educational Research and Training
NCTE	National Council for Teacher Education
NIE	National Institute of Education
NTP	National Teacher Platform
OER	Open Educational Resources
PL	Personalised Learning
PMU	Programme Management Unit
QCBS	Quality and Cost Based Selection
RCT	Randomised Controlled Trials
RFI	Request For Intent
RFP	Request For Proposal
RIE	Regional Institute of Education
RMSA	Rashtriya Madhyamik Shiksha Abhiyan
SCERT	State Council of Educational Research and Training
SIE	State Institute of Education
SOP	Standard Operating Procedure
SSA	Sarva Shiksha Abhiyaan
TaRL	Teaching at the Right Level
TEI	Teacher Education Institutes

1. INTRODUCTION

What is this guide

The 'Implementing Personalised Adaptive Learning at Schools: A Guidance Note for States' has been created to signal the commitment of the Ministry of Human Resources Development (MHRD), Government of India, towards developing the ecosystem for personalised adaptive learning in schools, and to support States who are interested in deploying it under the integrated 'Use of ICT in School Education' policy.

The recommendations in this guide are based on good practices drawn from early personalised adaptive learning solution deployment experiences in India, as well as from around the world. The guide covers why states should implement personalised adaptive learning solutions to enhance teaching and learning, and what could be done to ensure effective implementation across various stages. It offers advice on priority issues and on tackling practical difficulties, as well as risks, controversies or gaps in current knowledge.

Finally, it also offers guidance on how the massive volumes of student learning data that will be generated can be used to build a body of knowledge, a "Science of Learning Library", that can assist teachers, school administrators, researchers, and solution developers.

How to use this guide

Given the diversity of educational contexts across and within States, this guide is meant to be a reference that States should adopt but also feel free to tailor to their own circumstances. The processes recommended aim to encourage innovation and discovery of what works to continuously drive improvements in learning outcomes, and to ensure that students are benefitting from the best that the market has to offer. It is important that the procurement and implementation processes build India's personalised adaptive learning ecosystem by adding to the Science of Learning and incentivising technological innovation.

It would be useful for states to think of the following as essential parts of a successful roll out.

- **Operation and Maintenance (O&M)** of the hardware in schools to ensure uninterrupted uptime and access to the hosting server for running the Ed Tech solution
- **Hosting on DIKSHA,** the National Teacher Platform (NTP), for deploying the Ed Tech solution
- **Data-driven performance management**
  - Analytical back-engine of the EdTech solution to allow the provider to continuously refine based on feedback and performance
  - Dashboards for teachers, students and school administrators as well as education department officials at the cluster resource coordinator, block, district and State levels to provide visibility into usage and learning outcomes
  - A State-level control room that uses the dashboards and communication tools to provide supportive coaching and help build culture of performance in all parts of the education levels in the State
  - An institutional arrangement through which school-level learning outcomes, accuracy of diagnostics and appropriateness of suggested remediation pathways of the EdTech solution are measured and published every quarter
- **Capacity building**
  - Identifying a small group of teachers and education department officials and building their capacity to become master trainers

  - Training for teachers and education department officials on how to use EdTech as a tool to drive performance and on change management

- **A dynamic procurement process** that enables new players who demonstrate potential to gain access each year while allowing existing vendors to continue with originally allotted schools for multiple years
- **Aggregation of implementation data to the EdTech development community** through DIKSHA while protecting the intellectual property (IP) of the proprietary algorithm used by provider. This will drive innovation and enable disruption through dramatic improvements in the Science of Learning and adaptive learning algorithms

2. CONTEXT

2.1 The new paradigm of school education

India has made significant strides in access to education in the recent years. The country invested heavily in access and enrolment, building seven lakh new schools and adding 45 lakh new teachers to the education system from 1990 to 2015. Over this time frame, India's gross enrolment ratio (GER) at primary schools jumped nearly 20%, from 79% to 97%.

Unfortunately, while access to education has significantly improved, learning outcomes have not. Various national, international and independent surveys point to the low, and in some cases, even declining student learning outcomes in the country. According to the 2017 National Council of Educational Research & Training (NCERT)'s National Achievement Survey (NAS), over a third of students at Class 3 are not able to read a paragraph with understanding[1]. Over 40% of the students at Class 3 cannot use basic math to solve daily life problems. According to the NAS data for Class 5, **there has been a 6% to 33% decrease in learning levels between 2012 to 2015** for mathematics, language and environmental studies. The lack of foundational skills i.e., the ability to read with comprehension and use the basic mathematical operations in real life, are often binding constraints in developing any form of higher learning. Once students start falling behind, the losses only accumulate and worsen over time[2,3] . Clearly, the large increases in access have not translated to improved quality of education. Given this, there is now growing recognition of the importance to shift the policy focus from "outputs" such as student enrolment and attendance, to "outcomes" such as student learning.

[1] Analysis of NAS Class 3 data, 2017

[2] "Why Reading by the End of Third Grade Matters", Annie Casey Foundation, 2010

[3] Prof. Karthik Muralidharan. "Measuring Learning Trajectories in Developing Countries with Longitudinal Data and Item Response Theory", presented at University of Oxford, 8–9 July 2013

2.2 Using technology in education

India's Ministry of Human Resources Department (MHRD) aims to improve school effectiveness, equity and efficiency by merging the previously three separate centrally-sponsored schemes - Sarva Shiksha Abhiyan (SSA), Rashtriya Madhyamik Shiksha Abhiyan (RMSA) and Restructuring and Reorganising of Teacher Education (TE) — into Samagra Shiksha Abhiyan. The merger hopes to more efficiently allocate and use financial, human resources and institutional structures across these entities.

The integrated Samagra Shiksha Abhiyan brings an opportunity to make the previously under-utilised secondary school-focused ICT@Schools scheme more effective, by allowing for the funding to be used to purchase education technology (EdTech) infrastructure in primary schools. There is an opportunity to expand the scheme to use such infrastructure beyond just building ICT skills, to improve learning and teaching more broadly.

Globally, the EdTech space is rapidly innovating to provide solutions to suit diverse school contexts and needs. Depending on the infrastructure available and the quality of existing teacher training and instruction, below are examples of how technology is providing solutions to meet different needs:

2.2.1 EdTech to enhance learning in classrooms:[4]

- **Blended learning** is an instructional modality in which technology is integrated to deliver content. This can be implemented in various ways, such as showing videos to illustrate a concept and leveraging smart boards or personalised learning software.
- **Personalised adaptive learning** involves tailoring instruction to the learning levels of each child and leading the child up his or her unique learning trajectory. This note expands on this type of EdTech solution in subsequent sections.

[4] Central Square Foundation, "The EdTech Promise Catalysing Quality School Education at Scale", July 2015

2.2.2 EdTech to enhance learning outside the classroom

- **Social learning to enhance collaboration** whereby teachers use technology to enable frequent interaction between students by creating common workspaces for students and providing opportunities for dialogue with other students around the globe. Teachers also engage with professional communities to share best practices and support one another.

2.2.3 EdTech to enhance access to knowledge

- **Open access to democratise knowledge:** Several world-class universities provide Massive Open Online Courses (MOOCs), which allow learners to watch lecture videos and complete assignments online. Teachers also access free and open resources as well as participate in MOOCs for their own professional development and practice. They also contribute to Open Educational Resources (OER) repositories by creating and sharing their own material.
- **Virtual technologies for reaching students and teachers in large numbers** remotely for two-way interactive communication in real-time wherein local facilitators in the remote classroom lead and moderate discussions.

2.2.4 EdTech to strengthen the pillars of formal education

- **Management and communication technologies for effective classroom and school administration** involves classroom management applications to manage student behaviour and track attendance, grades and classroom participation[5], collaborative platforms used by school administrators to share resources and documents with their staff, information systems to track student and teacher, and online portals to provide access to student data to parents.

[5]"Classroom Behavior? There's an App for That," Edutopia, June 13, 2013, accessed October 16, 2014, http://www.edutopia.org/blog/classroom-behavior-classdojo-app-lisa-mims

- **In-classroom teacher support, which can address shortfalls in teacher preparedness** by providing digital training, instructional scripting and support materials that are tied directly to lesson content.

2.2.5 Miscellaneous

- **Mobile devices to increase penetration and enable anytime, anywhere access**: Several projects use mobile phones for developing literacy, promoting student motivation, enhancing access to teacher development opportunities, and improving communication between parents, teachers and principals.

2.3 What is personalised adaptive learning?

One of the most promising EdTech solutions to enhance student learning is personalised adaptive learning. Personalised adaptive learning solutions tailor instruction to the learning levels of each child, leading the child towards his or her unique learning trajectory. This pedagogical approach involves diagnosing the child's specific competencies, instead of testing for the child's knowledge on a broad topic. Once diagnosed, the child is led toward his or her unique learning path through a finite number of carefully designed questions, remediating with appropriate content where needed. For example, a specific subject could be broken down into key topics (e.g., whole number concepts), subsequently into clusters (e.g., counting and grouping up to 100), and then further into questions in order of difficulty. This would provide a comprehensive understanding of each cluster to the student.

The personalised adaptive learning approach is built on comprehensive and detailed concept dependency maps. If a learner is struggling with a particular concept, the product uses these maps to suggest earlier, more formative concepts that help the student better learn and master the concept. The questions should be challenging enough that they engage students, but not so difficult that they give up.

The robustness of personalised adaptive learning algorithms depend on the following three factors:

- The ability to identify the child's baseline on the specific topic or concept and lead the child up a learning ladder
- The ability to most effectively (in terms of facilitating the most organic process of moving up the learning ladder) decompose the learning ladder itself and construct the learning pathway
- The ability to most effectively remediate the child, using the most impactful content, for each competency deficiency

Personalised adaptive learning courseware typically show real-time progress dashboards of students' learning outcomes. Results can be aggregated and disaggregated, allowing different levels of analyses for policy formulation and implementation support. Such platforms would be helpful for parents, students, teachers and officials to understand the real-time student learning progress, and accordingly improve the efficiency of their intervention efforts. This can make teachers more valuable to the students as well by helping teachers better tailor their instruction to the students' learning levels and needs.

2.4 The case for personalised learning: evidence from around the world

Multiple studies around the world have shown that personalised adaptive learning is one of the most promising approaches to closing learning gaps. Several evaluations of the non-tech enabled "Teaching at the Right Level (TaRL)'' approach, which is effectively the pedagogical framework for personalised adaptive learning, have shown significant improvements in learning levels. However, given the complex nature of some of the TaRL approaches, it can be difficult to sustain the approach at scale.

There is encouraging evidence globally and in India on the use of computer-assisted adaptive learning to facilitate TaRL. A forthcoming paper by Philip Oreopoulos and Andre Nickow for J-PAL reviewed dozens of Randomised Controlled Trials (RCTs) involving EdTech. The research found that in nearly all of the 41 studies which compared students using adaptive software with peers who were taught by conventional means, the software-assisted students received higher scores.[6]

An extensive review of existing studies with attention to the details of CAL interventions found that hardware-focused interventions that provide computers at home or at school seem to have no positive impact on learning outcomes. Pedagogy-focused CAL programs that allow students to review grade-appropriate content at their own pace did better, but the gains were modest. Finally, the interventions that delivered the largest gains appeared to be those that use technology to also personalise instruction.[7]

Personalised solutions have been found to be effective for building foundational skills. A recent study through Randomised Control Trials (RCTs) of a personalised learning solution, Mindspark, in private off-school learning centres in Delhi found large increases in learning outcomes in terms of mathematics and Hindi in upper primary grades.[8] The resulting increase in learning outcomes were significantly higher than many effective interventions of comparable period of program exposure around the world. Based on this, a pilot in 80 schools covering children of Grades I-VIII across four districts of Rajasthan is currently in progress. The pilot evaluation is conducted by the same researchers and funded by the Global Innovation Fund. The RCT evaluation results of the first year of implementation validates the Delhi trials in regular government classrooms with promising improvements in learning outcomes from just over four months of implementation - this time seen in both primary (1-5) and upper primary (6-8) grades.

[6]The Economist, "Technology is transforming what happens when a child goes to school", July 2017

[7]Muralidharan, Singh and Ganimian, 'Disrupting Education? Experimental Evidence on Technology-Aided Instruction in India', July 2017

[8]Ibid

Given the low levels of foundational skills among students in India, personalised adaptive learning is especially promising for building such skills early on, so as to promote higher learning and prevent students from increasingly falling beyond later.

Research has shown that teachers also benefit through the introduction of personalised adaptive learning approaches, as student-specific diagnostics reduce the types of pedagogical errors they make and the prevalence of these errors.[9,10]

Prompted by the growing evidence on the efficacy of personalised learning solutions, the Chinese Education Ministry has mandated that governments at all levels spend no less than 8 percent of their annual funding on digitalisation, with specific focus on personalised learning.[11] The government has made artificial intelligence (AI) enabled education in schools a national strategy.

Taken together, the positive outcomes of these studies suggest that personalised adaptive learning methods has the potential to significantly influence student learning outcomes in India, especially to prevent students from falling behind early on. A coordinated approach between the Union and State governments will be important to ensure the implementation of this intervention is robust, focused and impactful.

[9]Carpenter, Thomas P., et al. "Teachers' Pedagogical Content Knowledge of Students' Problem Solving in Elementary Arithmetic." Journal for Research in Mathematics Education, vol. 19, no. 5, 1988, pp. 385–401., www.jstor.org/stable/749173

[10]Hill, H., Ball, D., & Schilling, S. (2008). Unpacking Pedagogical Content Knowledge: Conceptualizing and Measuring Teachers' Topic-Specific Knowledge of Students. Journal for Research in Mathematics Education, 39(4), 372-400. Retrieved from http://www.jstor.org/stable/40539304

[11]http://www.scmp.com/tech/science-research/article/2115271/china-wants-bring-artificial-intelligence-its-classrooms-boost

3. IMPLEMENTATION ROADMAP

How to implement personalized learning in schools?

It is important that States consider the implementation of any education technology solution in a gradual and phased manner. One of the important lessons on the implementation of education technology solutions, especially from the United States, is the need to exercise caution in the initial stages and allow both the education system and solutions providers to build the capacity to ensure effective implementation at scale. Further, given that high-profile deployments of computer hardware (such as the One Laptop per Child program) have been found to have zero impact on learning (because the hardware was not effectively integrated with pedagogy) it is also essential that the roadmap for scaling up education technology in India is accompanied by continuous independent evaluations on impact. This will enable scaling up of approaches that work and course correction of those that do not.

The first year iteration should, therefore, be used to bridge all information asymmetry and uncertainties to de-risk the implementation, for all sides concerned. It would effectively become a pilot stage to mainstream and scale personalised learning solution in the State. The solution can be scaled up gradually in the subsequent years, informed by the learnings from the pilot.

It is therefore recommended that states consider a multi-year implementation and phased roll-out. There are at least two reasons for this.

First, implementation of EdTech solutions in schools requires a careful period of testing, learning and refining in order to customize and contextualize a product and its implementation strategy to a local geography. In addition personalized learning interventions in schools require at least a 8 to 12 month period to demonstrate learning outcomes such as improvement in literacy or numeracy in students.

Further, the learnings from each year can feedback into the process so as to constantly refine it.

Second, these interventions require upfront investment in product development, and credible vendors would require some form of long-term comfort to justify taking this financial risk. Given the nascent nature of the market for personalised learning, it is necessary to incentivise both existing solutions providers to make the large necessary investments to innovate and improve their products as well as crowd-in new innovators.

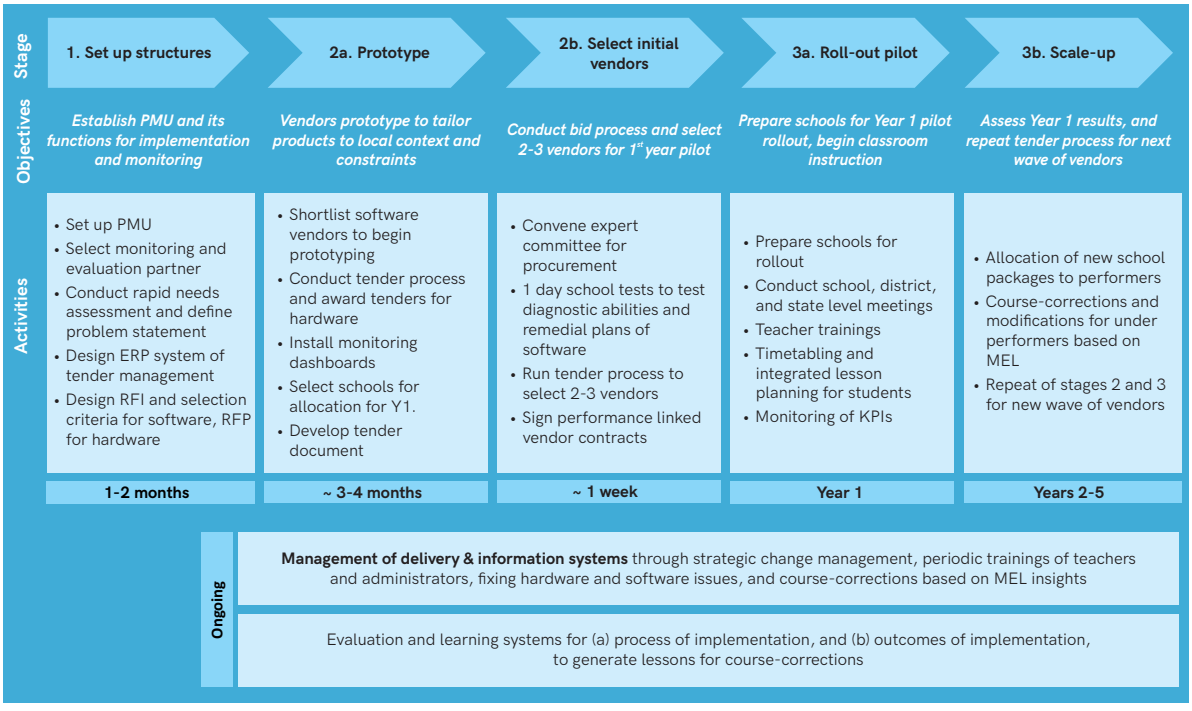
The State governments could therefore signal their commitment to a phased scale up of such solutions. States need to allow service providers sufficient time to prove the efficacy of their product, and create sustainable change in school systems before their contracts are modified or terminated. Any break in this implementation cycle can disrupt the rollout of school curriculums, and stop us from taking full advantage of the possibilities that personalised adaptive learning tools offer.

Accordingly, the States are recommended to follow a 3 step process to implement personalized learning in government schools in the state, as shown in figure 1. The 3-stage implementation is complemented by continuous ongoing monitoring, learning, and evaluation, and maintenance of delivery systems (human, and technological). These three stages are:

1. Setting up structures (1) within the state to ensure that the process of implementation is managed by a central agency with the power to administer, operate, and monitor, and hold stakeholders accountable for outcomes
2. Pilots and tendering (2a & 2b) to test shortlisted service providers in a real school setting, generate evidence on their efficacy, and select vendors with the best technical and financial proposals

3. Rollout and scale up (3a & 3b) to deploy hardware, software, and trainings in schools by selected vendors phase-wise, and monitor, evaluate, and learn before scaling up to wider geographies in the state

Figure 1. Implementation roadmap for personalized learning at schools



Broadly, states can follow three design principles that have been learned from local and global experiences of implementing personalized learning in schools. These are:

1. **Invest in getting buy-in early on, and align incentives of school-level stakeholders,** to make sure everyone works together to improve the learning outcomes of students
2. **Keep monitoring, evaluation, and learning at the heart of implementation,** to allow for continuous process and outcome improvements
3. **Be flexible and adaptive to the changing landscape of the EdTech market, of pedagogies, and of student learning needs,** and make programmatic adjustments at regular intervals to accommodate these changes

3.1 Set-up structures

Objective:	Activities:	Outputs:
To set up management structures and initiate processes for contracting	• Organization set-up and orders for PMU • Select monitoring and evaluation partner • Conduct rapid learning needs assessment and define problem statement • Design ERP system of tender management	• PMU installed • RFI and selection criteria for software, RFP for hardware • ERP installed • Contract management service provided by MoHRD

Implementation of personalized learning in schools, at scale, requires management of and oversight over multiple parallel processes with a large set of stakeholders: budgeting, strategizing, selecting vendors, tracking milestones, and recommending course corrections to partners. In order to do this efficiently, states are recommended to set up a Project Management Unit (PMU) at the outset.

An illustrative set of functions of the PMU include, but are not limited to:

- Team and relationship management with internal and externals stakeholders
- Budgeting for the scheme, and budget controls during project lifecycle
- Contracting and contract administration with EdTech vendors
- Oversight over monitoring and evaluation, disseminating insights to stakeholders, and recommending course-corrections to parties
- Overseeing change management across school systems

Given the multiplicity of functions and competencies required, and the day-to-day operational requirements of the PMU, states are recommended to contract-out some or all functions of the PMU to an external agency, depending on its preferences. A number of states are using a PMU model for large-scale public schemes successfully, including Chattisgarh, which has set up a PMU at the Chattisgarh Infotech Promotion Society (CHiPS) to implement EdTech solutions in state schools.

Aside from the ongoing project management tasks of the PMU through a project lifecycle, there are four critical tasks that the PMU should undertake to kick-off the project. These are presented below:

Task	Purpose	Illustrative Time period
Empanel the monitoring and evaluation partner for the project	The partner will clearly define performance metrics from the outset, and conduct initial analytical exercises listed below	3 weeks
Conduct rapid needs assessment at a representative sample of schools	To identify gaps in learning levels, prioritize classes and subjects for intervention, and define the problem statement to vendors clearly (e.g., target subjects and grade levels)	4 weeks
Identify various govt. and non-govt. financing sources, and requisition the Centre for ICT@schools budget	To receive funds from the Centre in time, activate internal sources of funding, and tap into philanthropic funding for a high-quality program	1 week
Define problem statement and release Request for Intent (RFI) document	To invite interest and early proposals from vendors for the prototyping phase	2 weeks
Set up ERP system at the PMU	To ensure clarity in procurement process and define key procurement parameters for the market	4 weeks

3.2a Prototype pilots

Objective:	Activities:	Outputs:
To test, refine, and contextualize personalized learning EdTech solutions before tendering	• RFI release and vendor shortlisting • Design RFP for hardware • Allocation of schools to shortlisted vendors for prototyping pilots • Development of monitoring dashboards • School selection for allocation in post-tender process • Development of RFP (tender document)	• Hardware tender and award to vendors • Software prototypes • List of schools for 1st year deployment • Software RFP document and scoring criteria

Implementation of any personalized learning EdTech solution should begin with a set of test pilots. Learning tools are most effective when they have been customized to the cultural (especially vernacular), infrastructural, and human resource contexts of a region. Hence, states should select vendors only after they have tested and prototyped their product, and proven its basic efficacy in a real-world setting.

In light of the innovative nature of the technology solution as well as information asymmetries associated with the first-time contracting, it may be appropriate to pursue a two-stage bidding process ('Manual for Procurement of Goods 2017, Ministry of Finance, Government of India' n.d.).

In the first stage an Expression of Interest (EoI) should be issued and bidders shortlisted based on past experience, performance capability, financial strength.

States can make available schools for 3-4 months to act as experimental stations to each of the shortlisted bidders at no cost to the government. Alternatively, they could be directed to work with the pilots already on in Rajasthan and Chhattisgarh and figure out the requisite information. During this period they can test and refine their product, and understand what it will take to achieve the quality states expect from them, besides figuring out their best possible bid quotes.

Pilot design and school allocation to vendors should be carefully thought through. Experiments with personalized adaptive learning in schools suggest that the earlier the interventions begin (e.g., in grade 1), the higher the learning outcome returns on investments made. In addition, most education specialists recommend starting with foundational skills of numeracy and vernacular literacy, before moving up to the skill ladder to english, science, and other school subjects. States can follow the same approach in early years of implementing personalized learning solutions in schools.

To some extent, software vendors should be allowed to prototype their product in a school environment that is conducive to technology absorption and systems integration. Otherwise, the software is likely to become side-lined by school-systems level implementation challenges. Hence, vendors should be allocated schools that meet a few essential criteria that make for good experimental conditions for personalized learning. These include (but are not limited to):

- Schools that have functional ICT infrastructure and hardware in place (computers, power, internet connectivity)
- Schools that are engaged with third party education services providers who are building capacity, improving school systems, and developing school leadership (e.g., Pratham, GyanShala, Educate Girls, etc.)
- Schools that have management that is proactive and willing to stand behind the systemic changes required for personalized learning interventions (e.g., training their teachers and changing their class timetables)

During this period, the evaluation partner empanelled with the PMU should measure the satisfaction levels of school subject teachers, computer room in-charge, and principals with the software, and seek feedback on their perceived ease of implementation of the solution. This will help provide valuable insights to the vendors to refine their product and can provide data points for vendor evaluation in the tender stage.

These conditions should also play a role in selecting and allocating schools to shortlisted vendors post-tender, for the rollout of the 1st year of pilots in the state.

The prototyping pilot period will yield two direct benefits to the state: (1) allow vendors to customize their product to a local context and provide better quality service, and (2) help states understand the requirements of a high-quality delivery system based on the in-school experiences of students, teachers, and management.

At this stage, Committee of Experts can be constituted, drawing in from among the most reputed sector experts from across the world, to help finalise the specifications as well as finalise the technical scoring of the RFP bidders. A good composition of this committee would include representatives from Dept. of Education, practitioners, teacher educators, subject matter experts, and technology experts. This committee can be formed at the Centre, with MoHRD offering the committee's expert advisory services to the states to help them with the tender management process. The Request for Proposal (RFP) document can be developed and refined during the pre-bid meetings and issued to the shortlisted bidders.

The tender for hardware should precede the tender for software, so that the necessary ICT and power infrastructure in schools is already set-up prior to the roll out of the personalized learning solution. Hence, states should consider tendering for hardware while software pilots are ongoing, so that software vendors are aware of the likely host machine for their software (and can make any modifications to their product). As in the tender process for software described in the next step, the state should select distribute school clusters to multiple instead of one final vendor, and avoid lump-sum upfront payments. Instead, the state should reserve part of the payment to clear hardware performance metrics (like total uptime of computers). This would reduce risks of dependency on one vendor for the state, and encourage competition amongst vendors for merit-based allocation of schools for the scale-up stage of implementation.

3.2b Tender finalization and award

Objective:	Activities:	Outputs:
To select the best software vendors for personalized learning and establish performance linked contracts	• Convening of expert committee for procurement • 1 day school tests of products to test diagnostic abilities and remedial plans • Tendering process to select 1-2 vendors from pilots • Performance linked contracting for 5 years, contingent on results	• Q score for QCBS • Change management SOPs • State coordination committee plans • State-vendor contracts

As next steps, vendors who go through the pilot should go through a formal tendering process. As data from the prototyping pilots begins to stream in, the shortlisted bidders would submit their respective offers on a two-cover bid – the first cover being the technical proposal and the second being the commercial quote ('Manual for Procurement of Goods 2017, Ministry of Finance, Government of India' n.d.). The details of the technical scoring matrix, technical specifications of the hardware and software, and bid parameters should be finalised with great care. These should take into account the results from the one-day quality tests in phase 2b.

It is useful to not lock the system into contracting with just one provider. Given that this is a rapidly evolving market and the enormous uncertainties and challenges associated with implementing such solutions in the difficult environments of public schools, the contracts should be awarded to multiple, preferably 2-3, software providers in each state. This would also provide the opportunity for software vendors to compete with each other, and for the state to learn from the comparative successes and failures of vendors in order to continue innovating in the next iterations of implementation. A set of design principles for a fair and clear procurement process are shown in **Figure 2.**

The State governments interested in pursuing this approach should publicize their intent to continue piloting and programming in schools for at least a 3-5 year period. This can be significant step in market catalysis in an emerging and rapidly evolving area like personalised learning, a classic example of how public policy can help with scaling up technology innovations. It would provide market participants with information which can be used to justify the significant necessary upfront investments.

This tender process can be repeated every year so as to expand the coverage as a single-stage two-cover tender. This would both

enable the government to incorporate learnings from each year of implementation and keep the specifications up to date. The technical specifications should include a line for previous year's performance so as to incentivize the incumbents to strive for excellence.

Figure 2. Design principles for a transparent and quality-based procurement process

1	Employ a scoring matrix for the technical specifications to ensure that commonly observed problems like bunching of scores etc. are avoided
2	Group schools/classes/grades for each bid category
3	Bid design should allow multiple providers for each bid category
4	Link part of the payment to the realization of outcomes targeted. This can be on a graded scale with incentive payment for higher outcomes realization
5	Define Service Legal Agreements (SLAs) practically, given first mover challenges and uncertainties faced by all sides, especially the providers
6	Allot new schools to providers in subsequent years based on outcomes realized to incentivize the originally successful bidders invest in building capacity for scaling
7	Score the financial and technical bids to select the successful bidder
8	Break up financial parameters in the bid into a one-time upfront development payout and recurring payouts, based on success, to ensure no front-loading by bidders

3.3a Roll-out

Objective:	Activities:	Outputs:
Prepare schools for implementation and begin rollout of lessons in classrooms	• School preparation, and school, district, and state level meetings • Teacher trainings • Monitoring of KPIs • Timetabling and integrated lesson plans for students	• State and district coordination meetings • Teacher trainings • Classroom lessons • Quarterly MEL result reports • Contract review methodology for existing vendors

Before PL classes are rolled out, the external evaluation partner should conduct a baseline study of student learning levels in target classes and subject areas across schools, so that the impact of PL classes can be measured during (midline) and at the end of the intervention period.

The state should plan the entire tender and rollout process such that rollout of personalized learning at schools happens at the start of the academic year. Once software vendors have been selected, states should prepare schools for implementation. State and district level meetings should be convened to work plan, and allocate roles and responsibilities to government personnel, who should be sensitized to the KPIs they will be held accountable for. At the school-level, the vendor and state should begin conducting teacher trainings, and conduct meetings with parents and school management to get their alignment and approval.

Once the software has been installed, and dry runs conducted by the vendor to iron out any delivery issues, classes can begin. The MEL partner should begin collecting data on key process and outcome indicators, and produce daily, weekly, monthly and quarterly reports for various levels of coordinators at the school, district, and state level. During this rollout period, the control room at the PMU should be using the monitoring dashboard actively to fix any issues that arise with delivery of personalized learning modules, and pass relevant orders to stakeholders to problem solve with immediate effect. At the school level, review meetings with the principal and district coordination committees should plan refresher trainings for teachers, and contact the software vendor for support as and when required.

3.3b Scale-up

Objective:	Activities:	Outputs:
Expand program to new schools, repeat vendor selection and tender process	• Allocation of new school packages to performers • Course-corrections and modifications for under performers based on MEL • Repeat of stages 2 and 3 for new wave of vendors	• Year 1 performance evaluations • Phase 2 vendor selection and contracting • Release of update of science of learning by NTP • School allocation for Phase 2

Towards the end of the 1 year period of rollout, the MEL partner should submit a final report on the impact of each set of interventions on the learning outcomes of students in each school.

At this stage, the state procurement team should repeat steps 2 and 3 to invite proposals from a new set of vendors for the next batchof schools. This would help ensure that the state is not locked into software vendors from Year 1 and any improvements in the pedagogy and analytical capabilities of personalized learning EdTech can be brought into schools immediately. The year 1 vendors will however have some advantage because the learning outcomes from their work would have been assessed and accounted for.

New software vendors should compete with existing vendors for the next phase of schools, by going through the same process of prototyping, testing, and tendering that was followed in year 1. Their products would compete with those of existing vendors, except that existing vendors would have their pre-existing end of one year learning outcome scores "O" given due weight to the "Q" score given by during the blind marking by the expert group at the time of the year 2 tender. Overall, the best performing vendor (hardware and software separately) from the previous year should be awarded with the next phase of schools. Others who have performed below the best should be retained in their current set of schools, and given time to improve their product. While doing so they will provide competitive pressure to the best performing vendor in the state. New vendors who qualify and are as good or better than existing ones would be allocated a set of schools just as in year 1. The MEL partner should also synthesize learnings for each vendor every quarter, and have the PMU recommend specific course corrections to those not delivering optimum outcomes.

This contracting and scale up loop should be followed at the end of every year of implementation, until all target schools in the state have been covered, by which time the state can do a strategy refresh based on a state-wide longitudinal study of student learning levels.

3.4 Managing delivery and information systems

Objective:	Activities:	Outputs:
Ensure all mechanisms of managing and delivering PL to students are functioning smoothly and following standardized procedures	• Integrate KPIs into teacher performance appraisals • Conduct regular refresher trainings for teachers • Convene local, district, and state level coordination committees for routine problems solving • Pass order to software and hardware vendors in case of under-perfomance on KPIs	• State and district coordination meetings • Teacher refresher trainings • Government orders for teacher KPIs and performance appraisals • Penalties on underperforming vendors as per contractual recourse mechanisms

Improving learning outcomes for students in government schools is the responsibility of the state. While EdTech vendors can provide products and services that contribute to this end goal, the state education machinery must ensure that all necessary systems of delivery under its control work towards this goal tactically and strategically. On one level, this means that government staff at the state, district, block, and cluster level understand the objectives of personalized learning tools clearly, are allocated roles and responsibilities, and held accountable to certain key performance indicators (KPIs). More broadly, however, personalized learning requires deep and well-informed changes to the method of school management, teacher instruction, and student experiences in classrooms, such that schools become capable and prepared to integrate their objectives with those of the education technology service provider. Ultimately, school systems need to evolve holistically in order to provide a more student and learning centred education model.

This requires a dedicated process of change management to ensure that the behaviours, activities, and performance of all personnel evolves to support the delivery of personalized learning lessons. An essential part of the change management associated with such initiatives is its ownership by teachers. This assumes even greater

significance given the concern that teachers could view personalised learning as a rival teaching method, an instrument that could be perceived as marginalising them. It is therefore important that teachers and education department officials undergo a sensitization workshop prior to roll out to understand the relevance of personalized learning in helping them achieve their objective of realising student learning outcomes.

There are two categories of delivery agents that are important for the successful implementation of any personalized learning solution - field implementation and monitoring.

The first are subject teachers, computer teachers and headmasters, who should ensure that the schedule and curriculum for personalized learning is well integrated with timetables and lesson plans, that students attend their personalized learning classroom lessons regularly, and that students have adequate time in front of the terminal (the computers running the software) to receive the recommended dosage of tutorials and remediation. These roles must be clearly communicated to teachers, and KPIs should be inserted into their performance appraisals.

Training is critical to effective implementation. For personalized learning to be effective, teachers should be trained both in the use of the basic hardware hosting the application, as well as in the use of the application itself, so that they are able to use these tools to support and handhold students in their journey. States should ensure that the software vendor develops a schedule, curriculum of teacher trainings and online tests and certification arrangements (both mandatory and optional using face to face and blended methods), and delivers these to teachers before and during program rollout. Another important component of teacher training is in lesson planning, so that teachers are able to integrate their curriculums with that of the personalized learning tool, and have the two complement each other.

It helps to have a dedicated statewide teacher training team (staffed jointly by experts hired by the software vendors, as well as

teacher trainers within the government) that visits schools at regular intervals and provide guidance. States should also ensure that the software vendor develops a Standard Operating Procedure (SOP) for teacher trainings so that the process become routine, automatized, and eventually, institutionalized within the government. States can do so by making these key outputs part of the SLAs in the contract with software vendors

A summary of the key features of the change management process at the school level are given below:

School systems feature	Change required
School administration - class schedules and lesson planning	• Update and streamlining of school timetables to accommodate personalized learning classroom sessions • Detailing of personalized student timetables to distribute students in different classroom slots to maintain 1:1 student-interface ratio • Lesson linkages between subject lesson plans and personalized learning software plans • Incorporation of remedial plans and pathways into regular subject classes
School administration - curriculums and pedagogy	• Integration of personalized learning curriculum with state and national curriculums • Integration of hardware with forms of instruction at schools more broadly • Use of PL software for proactive, unscheduled remedial support to special-needs children
School administration – vision and mission	• Adoption of personalized learning as a school-wide principle, and education philosophy • Insertion of KPIs to school-level stakeholders • Insertion of personalized learning into school-wide workplans

School systems feature	Change required
Teacher and instructor knowledge and skills	• Awareness and recognition of technology as an aide for learning outcomes • Digital literacy and adeptness with conventional hardware – desktop computers, laptops, tablets, and mobile phones • Basic software literacy - navigation and troubleshooting of computer applications • Soft skills for personalized student mentoring and counselling
Teacher professional growth and incentives	• Career counselling and mentorship for teachers and their role in the future of EdTech-integrated classroom education • Development of career growth plans and future avenues for pioneering teachers • Insertion of key performance indicators (KPIs) relevant to delivering personalized learning in professional appraisals • Sensitization and alignment to KPIs with teachers and instructors • Incentive structure to reward teacher performance for improving learning outcomes

The second set of delivery agents are education department officials who coordinate, guide, and supervise education delivery at the school, cluster, block, district, and state levels; principals of schools, cluster coordinators, block and district education officers, and the teams of the respective State Project Director and Commissioner of School Education. A governance mechanism (Control Rooms with communication tools) which cascades down from State to the Block and CRC levels, is critical to bring accountability and thereby ensure the successful implementation of a personalised learning solution.

The governance mechanism should be organized in coordination committees at different levels that review the performance of the program at frequent intervals. For example, school principals should take weekly stock-take of the total uptime of computers, and classroom and interface time of students, and motivate course corrections in case performance benchmarks are not being met. Similarly, block and district level administrators should conduct fortnightly review meetings to identify schools that are under-performing, identify the source of issue, and pass relevant orders to principals or the software vendor to resolve the underlying issues while applauding good performing ones.

The hardware hosting the personalized learning application is also an integral part of delivery. For lessons to be delivered to students effectively, computing machines must operate smoothly for more than minimum threshold of time per month, and they must operate with no to minimal glitches (e.g., processor hanging, screen blacking, etc.). This operational efficiency must be maintained by the hardware vendor, and his intermediate and final payments linked to the successful attainment of computer KPIs.

Monitoring inputs, activities & outputs

In order to ensure accountability and align incentives of key actors across the educational value chain, from students, teachers/coordinators, school administrators, block and district officers, and all the way up to the state PMU, it is important to put in strong Management Information Systems (MIS) for the government to monitor key inputs, activities and outputs, with intuitive and easy-to-use dashboards for reporting. The reports for monitoring and supervision should emerge from the MIS, almost exclusively from digitally obtained back-end data, and thereby avoid the need to have teachers spend time collecting and submitting reports upwards. All monitoring and supervision across levels should revolve around the Dashboards. There should be periodic trainings for education department officials on how to use the MIS and control room to capacitate and incentivise HM's, computer lab in-charge and subject teachers.

Some sample KPIs to track include:

Inputs:

- Number of devices installed and operational
- Number of teachers/school administrators trained

Output:

- Usage of PL - software uptime, number of sessions held, number of sessions held per dosage, average session length, % of students that login per session
- Access to PL - hardware uptime
- Remediation dosage - number of students identified for remediation and attended remediation, number of remediations planned and conducted

The usage KPIs should be monitored in real-time whenever there is connectivity, so that in case of any unusual inactivity, problems can be tackled as soon as possible.

In addition to investing in quality MIS, the states should invest in thorough training and building incentives for timely and accurate reporting.

An illustrative set of roles and responsibilities for delivery systems is shown in Figure 2. In order to facilitate the process of managing and maintaining delivery systems as per KPIs, the PMU should build a dashboard that digitally consumes data from the software vendors and MEL partner. The dashboards should have the current status of KPIs - from the school level up to the state level - are tracked daily, and presented on an intuitive user interface to the entire spectrum of education department officials managing the program. At the highest level, this dashboard should inform the "control room" situated in the PMU, that should utilize daily, weekly, and monthly insights into program performance to hold internal and external stakeholders in charge of delivery accountable for outputs and outcomes.

Individual software vendors should have dashboards that cater to the needs of individual students, parents, subject teachers and headmasters.

Figure 2. Roles and responsibilities for delivery systems for personalized learning - An Accountability Framework

S.No	Activity	Role Allocation
1.	One-time trainings to teachers and students in immediate post-rollout	Software vendor
2	Stabilising the roll-out (intense phase for one month)	Hardware and software vendors and Teacher-in-charge
3	Ensure the MIS and other monitoring requirements are in order	Software vendor
4	Ensure computers are functional (charged, consumables, internet)	Hardware vendor
5	Ensure safety of devices and manage the computer room	Teacher-in-charge and HM
6	Ensure time-at-task in maximised	Class teacher
7	Periodic trainings and other support to teachers to enable them with effective facilitation of student engagement	Software vendor
8	Ensure that the HM and teachers are capacitated and incentivised to use the software to improve learning outcomes	Education Department Officials

3.5 Evaluation and learning

Objective:	Activities:	Outputs:
To measure the quality of program implementation and its impact on learning outcomes for students	• Development of monitoring dashboard with key process and outcome metrics, and KPIs for personnel • Monthly and quarterly district and state level performance review meetings • Synthesis of monthly and quarterly process and outcome performance for each school	• Monitoring and evaluation framework, methodology, and dashboard • KPIs for personnel and systems • Monthly, quarterly, and annual process and impact reports • Question bank and student performance data reports

Given the evolving nature of personalised learning solutions especially in government school settings in India, states are encouraged to invest in robust evaluation & learning processes to ensure successful implementation, to continuously improve based on what works and what does not, and to generate lessons for the broader India-wide and global community. This system should embrace four components:

- Prioritised learning agenda that focuses resources on testing the most important assumptions and questions that underpin personalised learning solution design and implementation at different stages.
- Ongoing experimentation through an iterative and flexible approach that readily informs the strategies of suppliers and the state.
- Generalisable insights that set out the do's & don'ts of designing and implementing personalised learning solutions in government schools across the state and in other states/countries.
- Targeted evidence from the experimentation that resonates with key stakeholders and that appeals to the broader community.

The goals of the evaluation and learning can evolve across the different implementation stages. In the 'Prototype' phase, it can focus on the state and suppliers more quickly gaining insights on some fundamental unknowns such as the current state of infrastructure (e.g., electricity, connectivity, roads), teacher/school administrator levels, student learning levels and cultural context, which can then inform the approximate costs of solution deployment, as well as technical requirements for both software and hardware, and teacher/school administrator training.

In the initial 'Roll-out', states can focus on close monitoring and a process evaluation/ implementation study to understand what commonly works or breaks down in different contexts, and the high-level effectiveness of different personalized learning solution packages.

In the 'Scale-up' phase, states need to continue to monitor the implementation as it scales up more widely to ensure fidelity, and should consider investing in rigorous impact evaluations, including to measure cost-effectiveness. Impact evaluations will also help states decide whether or not to renew contracts with service providers, and inform its rate of program scaling with each vendor.

Evaluation of Process

Process evaluation - an assessment of whether program activities have been implemented as intended - is particularly important when introducing something so new that 'evaluating' the 'impact' right away isn't that practical, especially where what is being implemented can change a lot during the course of the period being studied (in part as a result of what the researchers were finding). Evaluation of process will help ensure that delivery systems of PL function smoothly and are able to course-correct when problems are detected (as described in section 3.4). It will also help inform SOPs that are contextualized and account for the real-time challenges faced by principals, teachers, and education officers (which will be reflected in the process evaluations), and avoid reliance on overly theoretical procedures that may not have validity in the real world. For example, process evaluations may reveal that despite receiving standardized trainings, teachers in a certain district repeatedly fail to administer the right dose of PL to students. This may mean that the teacher training team should increase the emphasis of lesson planning and timetable development in their training SOPs for the next round of implementation.

Evaluation of Impact

It is recommended to have independent evaluations of the learning outcome impacts. Especially as some of the early implementation challenges are ironed out, it is important to evaluate the improvements in learning outcomes from the implementation in a practical and cost-effective, but credible enough, manner. The evaluation design should incorporate a control group where possible, in order to capture the

difference-in-difference of student learning levels vis-a-vis the counterfactual, which is the natural progression of student learning without the support of personalised learning EdTech.

One way to achieve this objective is to create a control group for the implementation without any bias to have randomised allocation. It may be set up as a natural experiment, where a certain number of schools are selected for overall scale-up across the multi-year time period and measurements are taken in each year across them as the intervention is rolled out to different ones in a phased manner. The States could assign schools to each rollout phase in a random manner.

A sample baseline, quarterly and endline, can be conducted on both the implementation and control schools by the external monitoring and evaluation partner empanelled by the PMU at the start of this process. The incremental impact of the intervention can be teased out by using the difference-in-difference approach. This (or its percentage improvement) can form the basis for evaluating the relative performances of the different software providers. Independent evaluations, even if on small sample basis, assumes even greater importance if the yearly tenders are predicated on the performance of the incumbent solution providers.

Further, such an evaluation can leverage standardised assessments such as National Achievement Survey (NAS) to allow for comparison of effectiveness across different vendors and solutions, and with other types of interventions (i.e., non-personalised learning solution models).

Besides, the States may also encourage the rigorous evaluation of implementation by reputed researchers. Multiple channels of independent evaluations would also help maintain the systemic integrity during implementation, and create a library of evidence for PL that will help both administrators as well as product developers improve future iterations of PL interventions.

4. SCIENCE OF LEARNING LIBRARY

What is the Science of Learning Library?

The Science of Learning library is a public encyclopaedia which documents methods of diagnosing student learning; subject-wise theoretical concepts, practical case studies, and common misconceptions; learning pathways between learning levels, and the knowledge prerequisites for each pathway. Service providers, teachers, educators and academicians can uses this repository of information to build new and constantly improving processes of student remediation. Surprising as it would seem, this library of knowledge does not exist anywhere, even in a disaggregated manner.

Consider this: a map product like Google Map or Waze or CityMapper is a combination of some stationary attributes and some form of value addition that range from just describing a fixed attribute to calculating distances and commute times, traffic conditions, availability of amenities and so on. This value addition leverages the power of software technologies and is the basis for innovation in this market segment. Once the stationary attributes become available as a public good, it lowers entry barriers for entrepreneurs, fosters competition, and creates the condition for mass flourishing of innovations.

On the same lines, any education technology solution to enhance student learning is built on a set of concepts, question banks (or instruments), and student responses. While not necessarily equivalent, these are comparable to stationary attributes in a map. Based on this starting point, the solutions provider generates learning algorithms which can personalise instruction to the unique needs of each student. This is the space for innovation - the most efficient and effective remediation of students. The objective of public policy should be to catalyse innovation in this space by lowering entry barriers.

Map-based solutions providers like Google do not sell their value proposition as ownership of base maps but the value-added service that draws on the map. Similarly, personalised learning providers have to be assessed not on their question banks but based on their innovation with rendition of the questions (gamification etc), unique remediation approach, personalised learning trajectory algorithm, and the solutions' ability to put all these together for each kid in the most efficient manner. In fact, assessing personalised learning providers on their question banks is more likely to skew the discourse towards static and one-to-many Education technology solutions.

There are three factors that would go into the body of knowledge that is called "Science of Learning Library":

1. carefully designed diagnostic questions
2. availability of large scale assessment data on student responses across student grades and performance levels
3. pedagogical research into how students learn specific topics and the kinds of errors they make.

Apart from the data from the solutions providers, as the implementation proceeds, there will be gradual accumulation of publicly-sourced questions, student responses, and remediation content. Teachers themselves would be a significant generators of learning content. Further, researchers too would contribute to the body of knowledge around science of learning. Even raw implementation data from across the country, if available in one place, can help with significant efficiency improvements, besides facilitating the ease of administration. It is therefore essential that the invaluable data so generated not be lost, and we create the conditions for its capture by mandating that the solutions be hosted, in a technically compatible manner consistent with IP protections, in a national platform.

It is here that the National Teacher Portal (NTP), DIKSHA, assumes significance. If all the personalised learning solutions implementation in different states can be intermediated in an appropriate and technically feasible manner through the NTP, then it provides the ideal platform to capture the body of knowledge that is generated from the implementation. Further, the data from such solutions will not be useful in itself and would require significant value addition to be actionable. The procurement documents for the personalised learning solutions can reflect the data and content protocols required for integration into the NTP. This can be done in a manner so as to not compromise the IP of the providers with respect to their algorithms that will drive their content. This body of knowledge can then become the basis for the "Science of Learning Library".

Teachers would benefit if they had a source of reliable, pedagogical data and insights into student learning, as would curriculum developers, educational software developers, students, and parents. Currently, such information is not available to teachers. There is fairly strong evidence that student data in these areas is stable and provides valuable insights into how students learn.

Some may assume teachers already have access to this data, both formally (through educational training and literature), and informally (learned on the job). However, there is some evidence to show that teachers consistently overestimate student performance in the vast majority of the questions by a significant margin.

Would teachers benefit from knowing how students perform, the types of errors they make and the prevalence of these errors? A number of researches suggest they do (Carpenter et al. 1988; Heather C. Hill, Deborah Loewenberg Ball, and Stephen G. Schilling 2008). If teachers are aware of the kinds of pitfalls accompanying student thinking, it seems reasonable that they could both anticipate or address it while teaching. They could use questions that can highlight the presence of such errors, design such questions themselves or even think about possible solutions to persistent student errors.

Even if such databanks and research are not widely available to teachers, are they at least available to researchers? We sometimes assume that the answer is yes, and may even have some resources in mind. Surprisingly, much of this information is not widely known or accepted among researchers, or, in some cases, known only to researchers working in very specific areas. (For example, data on multiplication performance may not be known at all; data on fraction comparisons may be available to researchers working specifically on that topic.)

A repository of information like this, if curated and made publicly available, can have enormous positive externalities. For a start, it would help teachers everywhere prepare classroom instruction in a much more scientific manner. Besides, it can be used by personalised

learning solutions providers to significantly shorten their product development and refinement cycles.

It can be a global public good, an example of how India can produce, rather than just consume, cutting edge research in an important area like pedagogy. This will provide the conceptual base for development of remedial solutions (including a personalized learning system) for any child, and will comprise tightly coupled cycles of Assessments and Learning that will be represented on a dynamic learning map that connects current learning state to a future (and past) learning state, furthering every child's learning goal. This will be critical for creating a scalable personalized treatment plan that is focused on issues in developing countries for which India can be the testbed.

Finally, as public policy in such nascent markets where enablers and lowering entry barriers are critical, the government's role has to be in creating the conditions for mass flourishing of innovations. Making available the basic ingredients to let the innovation space flourish should be central to this objective. This would also involve creating the conditions to ensure that incumbents do not become rent-seekers on the basis of entry barriers due to constraints of questions and accumulated student response data. A data depository like this can be invaluable in meeting this objective.

Private providers may hesitate in making available this information, especially their question banks. This would be more so in the early stages of implementation when such procurements are likely to be perceived as one-off and not part of an integrated national program. To recollect, in the initial stages of the map-based solutions market too, solutions providers considered the physical attributes too valuable. This changed gradually as the market matured and the developers realised their true value proposition.

Solutions providers realise that public schools offers a database – vast numbers of students and the diversity of their responses – that private markets cannot provide. This is the staple to build up the innovative algorithms that are uniquely customised to each child's learning trajectory. This is the space for innovation and would differentiate their solutions. It is therefore important to expedite this market development using multiple approaches. Foremost, signalling this process as multi-year and across different states, with

implementation intermediated through a single national platform, can significantly mitigate these concerns.

Further, at a time when data protection and privacy is at the forefront of public debates, it may be questionable to allow private providers ownership of the student assessment data. At the least, this data should be owned by the student and the government. But assessment data, by itself, without questions may be meaningless. Therefore, it is important to mandate that questions and content as well as usage and assessment data be made available by all vendors to NTP and that their proprietary algorithms use only the content and questions made available by them.

The details and conditions of such disclosure, consistent with IP protections, can be explained to them during the pre-bid meetings and incorporated into the tender documents. These documents can be standardised as model tender documents by MHRD for use by other following states. All these would help bring confidence to the developers that these procurements are part of a national project to implement personalised learning solutions, and thereby mitigate at least some of their concerns.

5. DELIVERABLES SUMMARY

The overall program deliverables are two-fold

Deployment of **personalised learning solutions** that lead to improvements in student learning outcomes

Capture of information and data generated to develop a **Science of Learning library**

These will be achieved through the deliverables by the hardware and software providers

Hardware provider deliverables

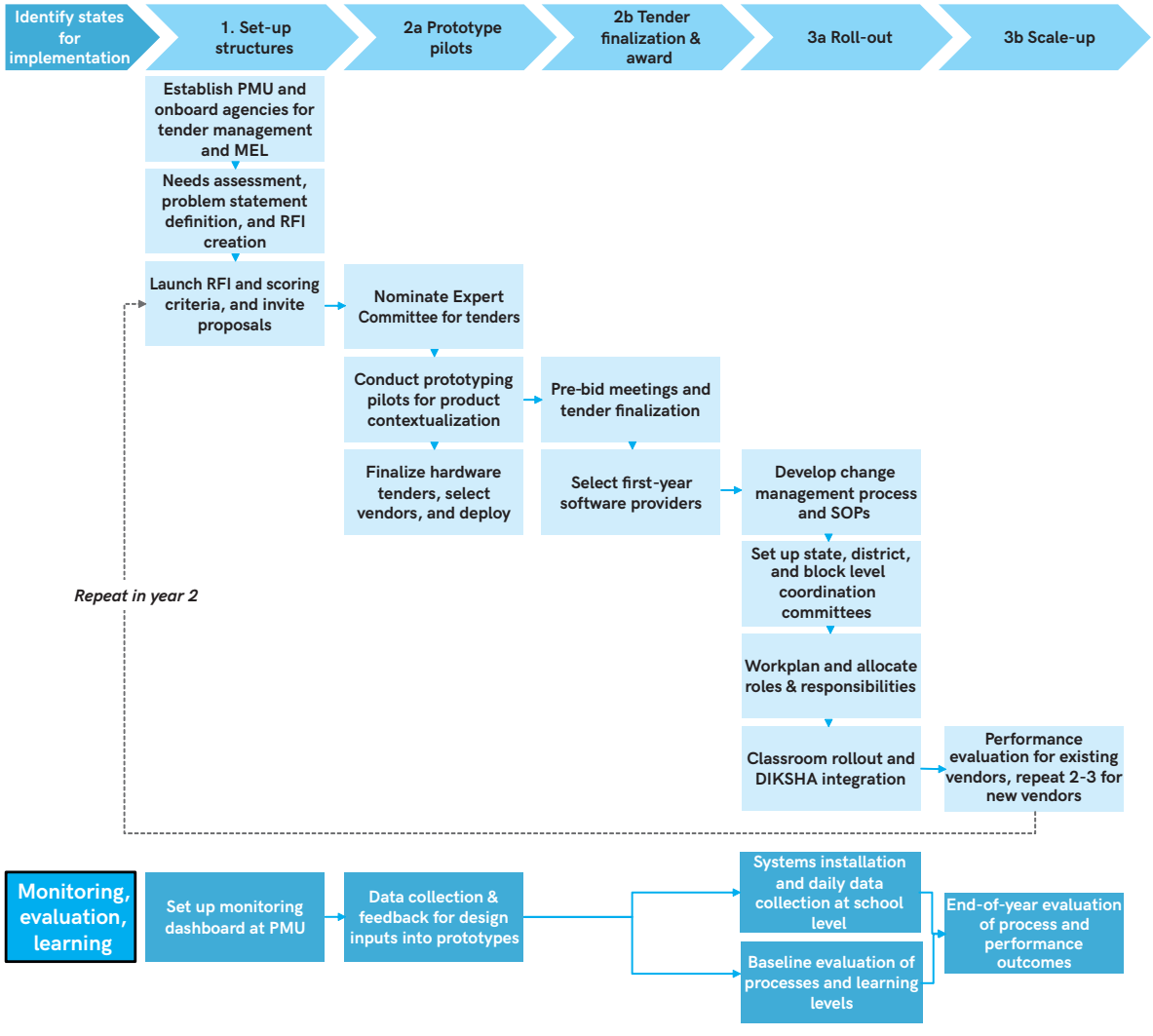
- Computers/tablets with required power back-up
- Ensuring that the systems are operational during the class hours

Software provider deliverables

- Personalised learning software, with defined specifications, and NTP integration
- A simple, user-friendly and customized MIS for guidance and monitoring by officials at different levels
- Periodic teacher training for effective facilitation of student engagement with the software
- Periodic training for state education department officials on the use of MIS to capacitate and incentivise HMs and teachers
- Personnel deployment in the state control room

The entire implementation will be the responsibility of the Education Department at all levels. The teachers and headmasters should be provided all the requisite implementation and capacity building support, including trainings. The supervisors should have a robust MIS that provides actionable decision-support and which is customised to meet the requirements at different levels.

6. SUMMARY OF THE IMPLEMENTATION AGENDA



7. ANNEX

7.1 DIKSHA and Science of Learning Architecture

DIKSHA Content Framework

Licensing Framework

The content on DIKSHA will be licensed under standard YouTube licenses, CC-BY (creative commons by attribution) or CC-BY-SA (creative commons by attribution and share-alike). The creative commons license framework allows content to be replicated/edited or used in any manner and settings (non-commercial or commercial) with correct attributions and acknowledgements of source and creators (while retaining the licence notice, in addition in case of CC BY-SA). The derivative works must be released using a license similar/identical to that of the base work.

Curation Process

Content is the backbone of teaching and learning. It is essential to monitor and review the large amounts of content available to be able to provide the most relevant and high quality digital content in a meaningful and organized way. The curation process on DIKSHA is envisaged to be an open process with low barriers to entry. Factors to be kept in mind to maintain the sanctity of the content are illustrated below.

- **Appropriate for students and teachers:** It is a process of shielding user from objectionable and inappropriate content by setting up policies & guidelines by a team of experts. This will be followed by mapping the content with the policy and guidelines to ensure compliance, failing which the content will be re-sent for review and removed from the platform, if necessary.
- **Usable across tools:** This is to ensure that users using different types of devices get a consistent experience of content. This will require evaluation of the content to avoid technical issues and any issues pertaining to the readability and sound quality of the text.

- **Tagged:** Reducing search and navigation time for a user with the help of robust tagging to taxonomy framework by tagging content at every level (chapter/topic/subtopic)post understanding search behaviour and conducive navigation hierarchies for users.
- **Quality checked:** The content should be quality checked to provide users with highest quality content in the most engaging format possible to enhance user experience and enable frequent use of the content. The quality of the content can be ascertained through the following aspects:
    - Rating –Rating of content will help provide qualitative feedback to creators or content providers to continuously improve content both in terms of interaction and contextualization.
    - Badging – Reputed, experienced organizationscan provide a 'badge' to signal quality, engaging content. This will help content creators/providers benchmarktheir content pieces with the 'badged' content leading to enriched user experience.
- **Staleness:** System performance can be maintained by evaluating data on content usage & defining guidelines so that the system automatically removes content that has limited or negligible usage to optimise user experience.

For detailed guidelines across different types of curation, refer to DIKSHA Content guidelines available on the DIKSHA Website.

Illustrative Diksha and Science of Learning Architecture