CENTRAL SQUARE FOUNDATION

IDinsight
DATA. DECISIONS. DEVELOPMENT.

The EdTech Lab Series

Insights from rapid evaluations of EdTech products

July 2019

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ABOUT CENTRAL SQUARE FOUNDATION

Central Square Foundation (CSF) is a nonprofit organisation working towards ensuring quality school education for all children in India. We are driven by the mission to transform the school education system towards improving the learning outcomes of children, especially from low-income communities.

To achieve this goal, CSF partners with social impact organisations to identify and support innovative solutions in education, as well as work with the Government to drive scalable, sustainable, and positive impact. We also collaborate with the private sector, nonprofit organisations, and other ecosystem stakeholders to build research and create effective proven tools around critical issues such as early learning, technology in education, classroom instruction methods and system governance.

Education Technology (EdTech) is a core part of the CSF's strategy and the goal is to leverage technology to improve foundational learning in primary classes and provide remediation support in upper primary and middle school. The three primary pillars of EdTech strategy include **supply shaping** to create a pipeline of contextualised solutions for the low-income segment; **evidence generation** around the efficacy of EdTech solutions in the Indian context; and supporting **government adoption** for an impactful and sustainable large-scale absorption of EdTech in the schools.

ABOUT IDINSIGHT

IDinsight helps leaders use rigorous evidence to improve lives. We tailor a wide range of analytical tools for our clients to rigorously test ideas, design effective policies, and take informed action at scale.

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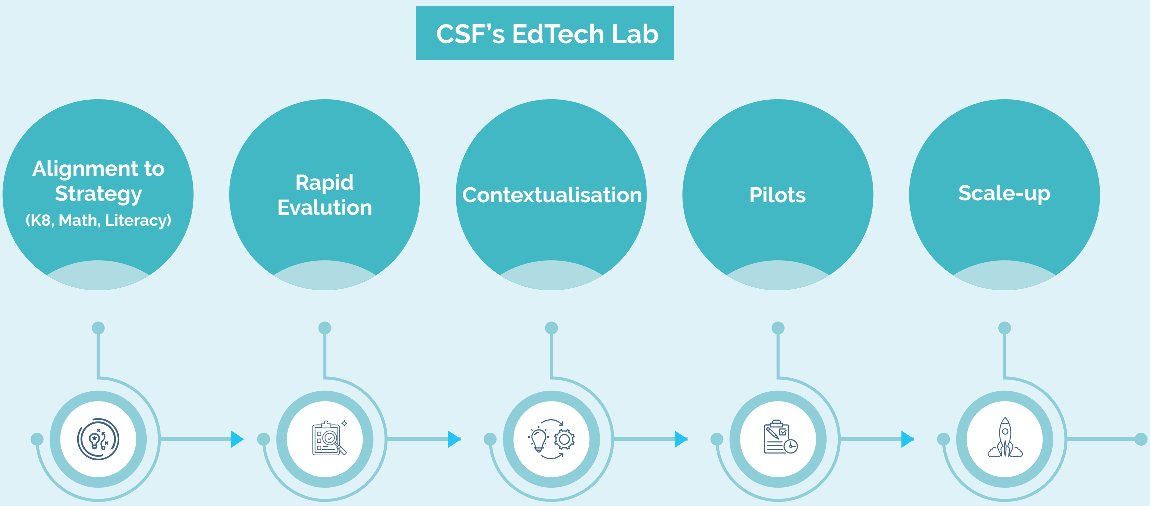
We have offices in Dakar, Johannesburg, Lusaka, Manila, Nairobi, New Delhi, San Francisco, and Washington DC. To learn more visit www.IDinsight.org.

ABOUT EDTECH LAB

In India, the deployment of EdTech has largely been sporadic and concentrated in specific geographies. There exists a very vibrant for-profit EdTech ecosystem catering largely to the middle and high-income segments. However, there is limited availability of vernacular products catering to the low-income segments. Additionally, there is limited evidence on quality, usability and efficacy of EdTech products. This becomes a big impediment for decision-makers including state governments to procure solutions. Thus, in 2018, CSF launched the 'EdTech Lab' initiative for:

- Identifying and building evidence around the efficacy of existing EdTech solutions in India
- Contextualising and creating a pathway for scale-up of promising solutions in government schools

To achieve the aim of catalysing the supply of contextual Ed-Tech solutions catering to low-income children, both in schools and homes, and in the process, build and disseminate evidence, EdTech Lab has been conceived as a staged process of evaluation as below.



Scope:
Grades: K-8,
Subjects: Hindi & Math,
Delivery models: In-school (PAL – BCR), At-Home (Student-led)

Rapid Evaluation:
12 shortlisted solutions to undergo qualitative evaluations, expert-reviews on product & pedagogy, analysis of existing usage data via a comprehensive evaluation toolkit

contextualization of products:
High performing EdTech solution to get contextualised for state implementation, which includes support for language translations, localisation of content and bridging interface and platform gaps for products

Pilots/test-beds:
The contextualized solutions to be implemented in 'test-beds', which are 50-100 school pilots designed to arrive at a scale-ready, sustainable and impactful model of their implementation

Scale up:
The proven EdTech solutions to scale-up to a larger number of schools in the State by the governments and/or other stakeholders, with the scale-ready implementation model arrived as a result of test-beds

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LIST OF TERMS

PRODUCT TYPE DEFINITIONS USED IN THIS REPORT

EdTech products do not have a standard naming convention. Below are the definitions used in this report along with a quick explanation on how other commonly used definitions align with them:

Instructional aids:
These products are sometimes referred to as digital classrooms, smart classrooms, blended products, techno-classes, or computer-assisted instruction products. Instructional aid as a term is intended to emphasize that the technology is used by the teacher to assist, but not replace instruction and that the mode of delivery is one-to-many.

Individual-use products:
These products are sometimes called personalised products, computer-assisted-learning products, or technology-aided instruction products. Use of the term individual-use is intended to signify only that the products are used one-to-one. Personalised adaptive products, described below, are a subset of individual-use products.

Personalised adaptive products (PAL):
These are individual-use products that use technology to match instruction to the learning levels of users. They may adjust the difficulty or change the number of questions in a topic based on students' performance in that topic. They may also determine which topics students should study based on ongoing in-app performance assessment.

ABBREVIATION

CSF	Central Square Foundation
CPU	Central Processing Unit
EdTech	Education Technology
EI	Educational Initiatives
K-8	Kindergarten to Grade 8
GoI	Government of India
INR	Indian National Rupee
NGO	Non-Governmental Organisation
MHRD	Ministry of Human Resource Development
MIS	Management Information System
PAL	Personalised Adaptive Learning
PTI	Press Trust of India
UDISE	Unified District Information on School Education
UPS	Uninterruptable Power Supply
US	United States of America
USD	United States Dollar

EXECUTIVE SUMMARY

REPORT INTRODUCTION

Education Technology (EdTech) has demonstrated significant potential to increase learning outcomes for students globally as well as in India. Access to EdTech products is rapidly increasing along with the infrastructure needed to use them. Yet, to date, the vast majority of EdTech investment and focus in India has been centred on students from high-income households. For EdTech to have an impact on education at scale, more products must be developed that offer vernacular languages, use appropriate cultural references, target a range of learning levels, and are sold at lower price points than many products currently in the market. Additionally, decision-makers not only need better evidence on suitable approaches that would work and have an impact in their respective contexts, but they also need guidance and support on deploying EdTech products in ways that increase student learning.

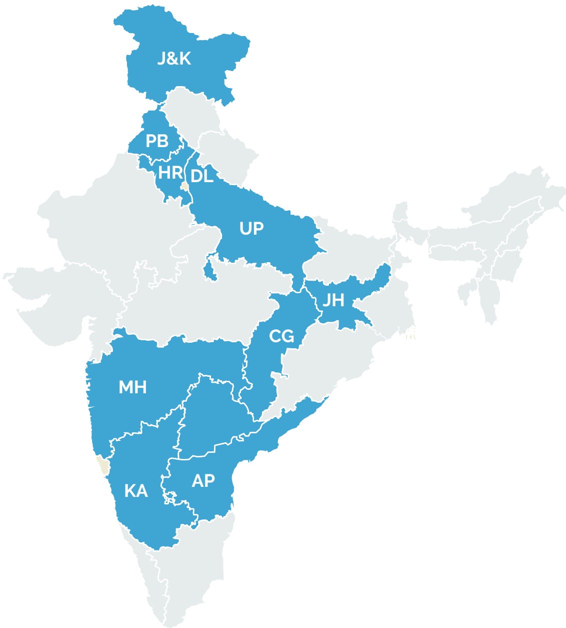

FIGURE 1: STATES VISITED FOR DATA COLLECTION

Interest in EdTech has been growing rapidly in India. This report aims to add data and insights to this discourse based on findings from the early stages of CSF's EdTech Lab. These stages include a landscaping exercise and 12 rapid process evaluations of promising products. Data collection for this work includes interviewing or surveying over 1,500 school staff members and students and analysing product-generated use data for over 17,000 students and 3,900 schools. The report provides insights for researchers, funders, product companies, and implementers on important dimensions of the current status of EdTech in India.

EXISTING EVIDENCE[1]

The following major themes are based on an evidence review of EdTech in low-income and middle-income countries.

- **Provision of hardware:** Mere provision of hardware is unlikely to improve learning outcomes.
- **Product type:** Both instructional aids and individual-use products have proven to be effective. Compared to instructional aids, individual-use products have a wider base of evidence showing they could improve learning.
- **Exposure levels:** The impact of EdTech products does not correlate with the total amount of time students use the products.

[1] References for these findings are in-line in the Evidence base for EdTech section. A table of studies for that these conclusions are based on is in Appendix 4.

Scheduling: After-school interventions are more likely to show positive effects. This may be because they do not replace teaching time. In-school interventions are more likely to show positive impacts when the quality of traditional instruction time that they replaced was low.

Subject focus: EdTech can be effective for both Math and language interventions. Studies which compare Math effectiveness to language effectiveness find that the interventions are either similarly effective or that they are more effective for Math.

Adaptivity: Interventions that leverage adaptive technologies to match instruction to the learning-level of the user have shown the largest effects. These adaptive products do not consistently benefit lower or higher performers more.

FINDINGS FROM PRODUCT EVALUATIONS

The following are major findings about product features and implementation strategies based on the findings of 12 rapid process evaluations.

PRODUCT FEATURES

Product type: No product type performed consistently better than the others. Overall performance depended on the details of the product's features and how it was implemented. Some products from the two major product types performed well against the Rapid Evaluation criteria while some performed poorly.

Features: Compared to other features, instructional videos and animations were used heavily in all types of products. Instructional aid products were used almost exclusively for showing videos.

Content:

- Hindi-language learning content was often poorly made and it was rarely used by students or teachers.
- Each subject was used in proportion to the amount of content offered for that subject.
- For the products to be used easily, the content needed to be deep in every subtopic and mapped carefully to the curriculum.

Delivery: Students struggled to use products when they were in non-native languages, contained unfamiliar examples, or had too much text.

Targeting: Few products matched instruction to the learning level of students. Teachers and student use patterns showed that both user types looked for capability-aligned content when available.

Data: The products' rich data sets were often not being effectively exploited. None of the 12 evaluated products were able to meaningfully track student learning. Dashboards were overly complex, and teachers rarely used them.

FOR IMPLEMENTERS – SUGGESTIONS FOR SELECTING AND ASSESSING PRODUCTS

Support: Consistently available technical support was important for sustaining usage in schools. Despite receiving training, teachers across products and implementation models needed regular, sometimes daily, help with simple tasks such as start-up and basic navigation.

Training: The training approaches cited as most successful by school staff included thorough, hands-on initial training along with regular refresher trainings. A cascading train-the-trainer employed by one implementer (the only example studied) did not work well.

Monitoring: Monitoring by administrators and school coordinators was correlated with higher product use. However, when monitoring was focussed on "use-hours," some teachers took steps to log use-hours without meaningfully using the product.

TOP FUTURE OPPORTUNITIES

The following future opportunities are based on an evidence review, a landscaping exercise, and 12 rapid process evaluations of products on the market in India. They represent priorities but are not exhaustive.

FOR FUNDERS AND BUSINESSES - GAPS IN THE MARKETPLACE

- Quality vernacular medium of instruction and vernacular-language learning products.
- Individual-use products that match instruction levels to student capability levels.
- Affordable and quality home-use products.

FOR RESEARCHERS - GAPS IN EVIDENCE

- Can EdTech products improve learning when used at scale in government school systems? Further, which product types, implementation models, and system-level structures are best-suited to improving learning outcomes when using EdTech?
- What degree of matching instruction to the learning level of students is most appropriate for individual-use products used in classrooms?
- Which pedagogical features are the most effective for improving learning?
- How does the effectiveness of instructional aid products change with how they are used?
- Which products are the most cost-effective for in-school interventions?

FOR IMPLEMENTERS - SUGGESTIONS FOR EVALUATING PRODUCTS TO BETTER GAUGE EFFECTIVENESS

Product Selection: Implementers should consider more than just product type when selecting products. Product type and features are not strong indicators of product quality. Implementers should look for products that have shown positive effects on student learning in similar contexts. They can additionally use the findings from recommendations based on Rapid Evaluation Findings as well as the Product Review Rubric in Appendix 4 to guide product selection.

Roll-out: Implementers should conduct a rapid, low-cost process evaluation shortly after initial implementation to assess how implementation is going and to identify potential course corrections.

Scale-up: Once the EdTech implementation has stabilised and is being scaled up, the implementer should conduct a rigorous impact evaluation to assess the impact of the product on student learning outcomes.

1

INTRODUCTION

Education technology (EdTech) has demonstrated significant potential for increasing learning outcomes for students globally and in India. In[2] Delhi, students who used an EdTech product in an after-school centre increased their math scores by twice the amount as opposed to a randomly assigned control group (Muralidharan, Singh and Ganimian 2019). In Punjab, Pakistan, a low cost EdTech product implemented in government schools similarly led to a doubling of learning gains in math and science (Beg, et al. 2019). At scale, these interventions could cost as little as ₹ 140 per-student per-year (Muralidharan, Singh and Ganimian 2019).

Further, rapidly increasing access to internet, smartphones, and other technologies has led to an expansion in the number of potential EdTech users. In 2016, 40 crore Indians had internet access and 29 crore owned a smartphone. By 2021, these numbers are expected to reach 74 crore and 47 crore respectively (Khaitan, et al. 2017). Accompanying these growing rates of access, the total market value of all EdTech products used online is large and growing quickly (by around 50% a year). This market is expected to value nearly ₹ 14,000 crore by 2021 (Khaitan, et al. 2017). In addition to sales, Indian companies are seeing massive investments. In 2018, India had the third highest levels of investment in EdTech globally (behind US and China) (Khaitan, et al. 2017).

Yet, to date, most EdTech products in India have focussed on high-income students. However, most students need products that offer different languages, use different examples and references, target different learning gaps, and are sold at different price points than the products currently on the market. If EdTech is to have an impact on education at scale, three key hurdles must be overcome.

- EdTech companies must develop products appropriate for low- and middle-income students and schools.
- More evidence must be generated on what EdTech approaches and products are effective, which are most cost-effective, and how they vary by context.
- Parents, schools, and state governments must be provided guidance and support in adopting, implementing, and evaluating EdTech products. They must be able to make decisions on adoption based on product effectiveness, and not be motivated only by hardware procurement.

This report is based on findings from the early stages of CSF's EdTech Lab. It begins by describing the Indian EdTech landscape and summarising the existing evidence on the effectiveness of EdTech in similar contexts. It then provides findings on EdTech features and implementation strategies. Finally, it provides recommendations to funders and investors on the most important gaps in the marketplace, to researchers on the most salient gaps in the evidence base, and to implementers on how to evaluate products they use.

The findings described here are drawn from an EdTech landscape research exercise as well as data collected while conducting rapid process evaluations of 12 high potential products. In the process, 44 schools were visited in 10 states; 685 teachers, administrators, implementers, parents, and students were interviewed; 981 students were surveyed; 41 classroom sessions were observed. MIS data for at least a year's history for 17,000 students and 3,900 schools was analysed. Six education and technology experts provided detailed product reviews.

[2] See Table of Reviewed Studies in Appendix 5 for a list of such studies.

2

EDTECH PRODUCT LANDSCAPE

DIFFERENT EDTECH APPROACHES

The term EdTech can cover a host of different product types with varied aims. This report, as well as CSF's EdTech Lab focuses on EdTech products that aim to improve student learning either through aiding in-classroom instruction by teachers or through direct use of the product by students.

EdTech products do not have a standard naming convention. Below are the definitions used in this report along with a quick explanation on how other commonly used definitions align with them.

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	PRODUCT TYPE		
	Instructional aids (digital classrooms)	Individual-use products (personalised learning)	
	School-based	School-based	Home-use
Description	Instructional aid used by a teacher to supplement lesson delivery with a full or partial classroom	Learning applications used 1:1 by students in a classroom or computer lab	Learning application used 1:1 by students independently at home
Hardware requirements	Smartboard, projector, or television	Computer or tablet	Computer, tablet, or smartphone
Common content elements	Instructional videos, activities, games, quizzes, lesson plans	Instructional videos, practice problems, assessments, games	Instructional videos, practice problems, practice tests, games, problem solutions

TABLE 1: OVERVIEW OF PRODUCT TYPES

INSTRUCTIONAL AIDS

OVERVIEW

EdTech instructional aids allow teachers to show content to an entire class of students using a smartboard or another type of screen. Teachers most commonly use these products to show videos, administer practice questions, run activities, or play games. They are typically implemented using a desktop computer, speakers and either a smartboard, projector, or television.

FOOTPRINT

Instructional aid products are increasingly common in government and private schools. The Ministry of Human Resource Development (MHRD) plans to put EdTech instructional aid products in every grade from 9-12 and in tertiary classrooms by 2022 (Business Line Bureau 2019). Kerala has installed the necessary hardware to deploy instructional aids in more than 40,000 classrooms and plans to train teachers to use them online (PTI 2018). The Gujarat government aims to use instructional aids in over 1,600 schools (over 3,000 classrooms and 2 lakh students) for Grades 5-8.[3] The Andhra Pradesh government is already using instructional aids in over 3,500 schools and plans on expanding to another 1,500 over the next year. These products are prevalent across private schools as well. For example, as early as 2013, 58% of affordable private schools in Hyderabad had instructional aid technology in at least some classrooms (Campbell, Mehr and Mayer n.d.).

INDIVIDUAL-USE PRODUCTS

OVERVIEW

Individual-use EdTech products use a student-centred model where students interact one-on-one with an educational software. The software features vary based on the product. The features commonly include instructional videos, practice questions, assessments, and games. They are typically used on computers, tablets, or smartphones and can be used in schools or at homes. In schools, they are most often used in dedicated computer labs or through tablets in classrooms. In homes, they are most often used on smartphones, tablets, or computers.

A subset of individual-use EdTech products are adaptive products which are sometimes called Personalised Adaptive Learning (PAL) solutions. These products dynamically tailor the teaching instructions to the learning levels of the user and lead them through a unique learning trajectory. Ideally, they should be able to identify the user's ability levels, construct different learning pathways based on capability, and identify and remediate competency deficiencies.

FOOTPRINT

Individual-use products are seeing increased interest from home-based users, government bodies, and private schools.

Home-based products targeted at primary and secondary students had nearly 5 lakh paid users in 2016 and a total market value of ₹ 511 crore (Khaitan, et al. 2017). In the same year, the total market size was predicted to rise by 60% per year through 2021 driven by increasing internet penetration in tier two cities and rising acceptance of online education.

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[3] See note by the Education Department, Government of Gujrat on the "Gyankunj Project". Available at: http://gujarat-education.gov.in/ssa/projects/gyankunj.htm

The use of individual-use products in schools, including PAL products, is also rapidly increasing. In 2018, MHRD issued guidelines for states on implementing PAL products (MHRD 2018). Various state governments have started implementing these products in schools. For example, in Rajasthan, a PAL product called Mindspark is running in 70 government schools across 4 districts.[4] In Chhattisgarh, the same product is being run in 26 schools in the resource-constrained districts of Dantewada, Bastar, and Rajnandgaon.[5] Andhra Pradesh is launching a pilot of multiple individual-use products across 60 schools and targeting scale-up to over 2600 schools.[6]

INFRASTRUCTURE INPUTS

Hardware availability is an important input into understanding the feasibility for EdTech. Currently, levels of access to the necessary inputs (hardware, electricity, internet) are low (U-DISE 2017).[7] Less than 20% of schools have computer labs or hardware for individual-use products. Slightly more than 20% of Indians own smartphones. However, access rates to technology such as smartphones, and internet are expected to increase rapidly. See Appendix 1 for data on current and projected levels of access to inputs.

Additionally, the costs and relative costs of each technology are important for implementors making decisions about how to allocate education funds. Appendix 2 provides a summary table on the costs and feature trade-offs for different product types.

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[4] See the project note by implementers, and the maker of Mindspark, Educational Initiatives (EI). Available at: https://www.ei-india.com/lsep

[5] See CSF's note on Government Adoption of EdTech in India. Available at: http://www.centralsquarefoundation.org/edtech/government-adoption/

[6] See Request for Proposal from the Commissioner of School Education, Government of Andhra Pradesh. Available at: http://cse.ap.gov.in/DSENEW/JSP/GoAP%20PAL%20vendor%20selection%20EoI-min.pdf

[7] All school hardware data from data from Unified District Information on School Education (UDISE) for the year 2017. These numbers could be marginal underestimates of the actual number of students that have access to this infrastructure. Larger schools that have more students have better infrastructure on average.

3

EVIDENCE BASE FOR EDTECH

The following is a review of the available evidence on EdTech interventions from low and middle-income countries. It focuses only on studies that used computers (but not televisions or phones) increase learning in traditional subjects. Studies that aimed to build only computer literacy skills have not been included.

Further, only studies that employed randomised designs have been reviewed. While quasi-experimental designs may, under certain conditions, yield high quality evidence; assessing whether these conditions are met for educational interventions can be difficult or impossible.

In total, 14 studies covering 27 interventions were reviewed (henceforth 'reviewed studies' and 'reviewed interventions' respectively).[8] See Table of Reviewed Studies in Appendix 5 for a summary.

The reviewed studies show that EdTech can improve learning outcomes in contexts relevant to India. However, not all evaluations have shown positive results and one intervention even showed large negative results.

Discussed below is the effect of EdTech interventions as they vary across six key parameters: (I) provision of hardware, (ii) product type, (iii) exposure levels, (iv) scheduling, (v) subject focus, and (vi) adaptivity. While various insights relevant to each of these parameters have been drawn from literature, the overall evidence suggests that details of the interventions are crucial. These six factors are likely to interact with each other, making the individual contribution of any one of them uncertain and highly context specific.

Intervention effects are expressed in terms of Standard Deviation (SD) gains or losses on normalised test scores for the subject(s) in question.[9] While there is no clear benchmark for what counts as a "meaningful" effect, any effect size greater than 0.1 SD can be considered modest. Any effect size of 0.25 SD or more may be thought of as "substantively important" (WWC 2014 as cited in Kraft 2018).[10]

PROVISION OF HARDWARE

Simple provision of hardware is unlikely to improve learning outcomes. In all studies where EdTech products were shown to have effects, teachers were trained to integrate the products with instruction in some way or student time was focussed on using some educational software. A review of nine evaluations of hardware-focussed interventions across geographies finds they often led to limited or no impact.[11] While hardware is a necessary input, it is unlikely to lead to learning without integration with an intentional pedagogical strategy. This is an important finding for governments who are often able to procure and install hardware more easily than they can change within-classroom practices.[12]

[8] Technically, 22 treatment arms across the 15 studies were included. Some studies had multiple target subjects but evaluated them using the same treatment arm. In such cases, for the sake of simplicity of reporting, results for each target subject were counted as unique treatment arms.

[9] Interpreting standard deviations in education interventions should be treated with caution. See Singh (2015).

[10] See Kraft (2018) for a broader discussion on interpreting effect sizes for educational interventions.

[11] See Online Appendix C in Muralidharan, Singh, and Ganimian (2019).

[12] See Pritchett's arguments about 'isomorphism' and the provision of education (Pritchett 2018).

PRODUCT TYPE: INSTRUCTIONAL AIDS AND INDIVIDUAL-USE PRODUCTS

Both instructional aids and individual-use products have shown they can work in some situations, though more evidence shows that individual-use products can improve learning. Products used individually have broad evidence of leading to learning gains in different contexts. Of the 21 reviewed interventions with individual-use products, 13 showed positive and significant impacts. Some showed effect sizes approaching 0.4 Standard Deviations (Banerjee, et al. 2007; Carillo, Onofa, and Ponce 2010; Muralidharan, Singh, and Ganimian 2019). However, seven interventions found no effects on learning and one showed highly negative effects (Linden 2008).

Instructional aid products have less evidence of effectiveness in low and medium-income countries. Of the six reviewed interventions, only one study (with two treatment arms) showed significant positive effects on learning (Beg, et al. 2019). However, the study importantly demonstrated that EdTech instructional aids can be cheap and effective.[13] Figure 2 shows the estimated effect sizes of the reviewed treatment arms by product type.

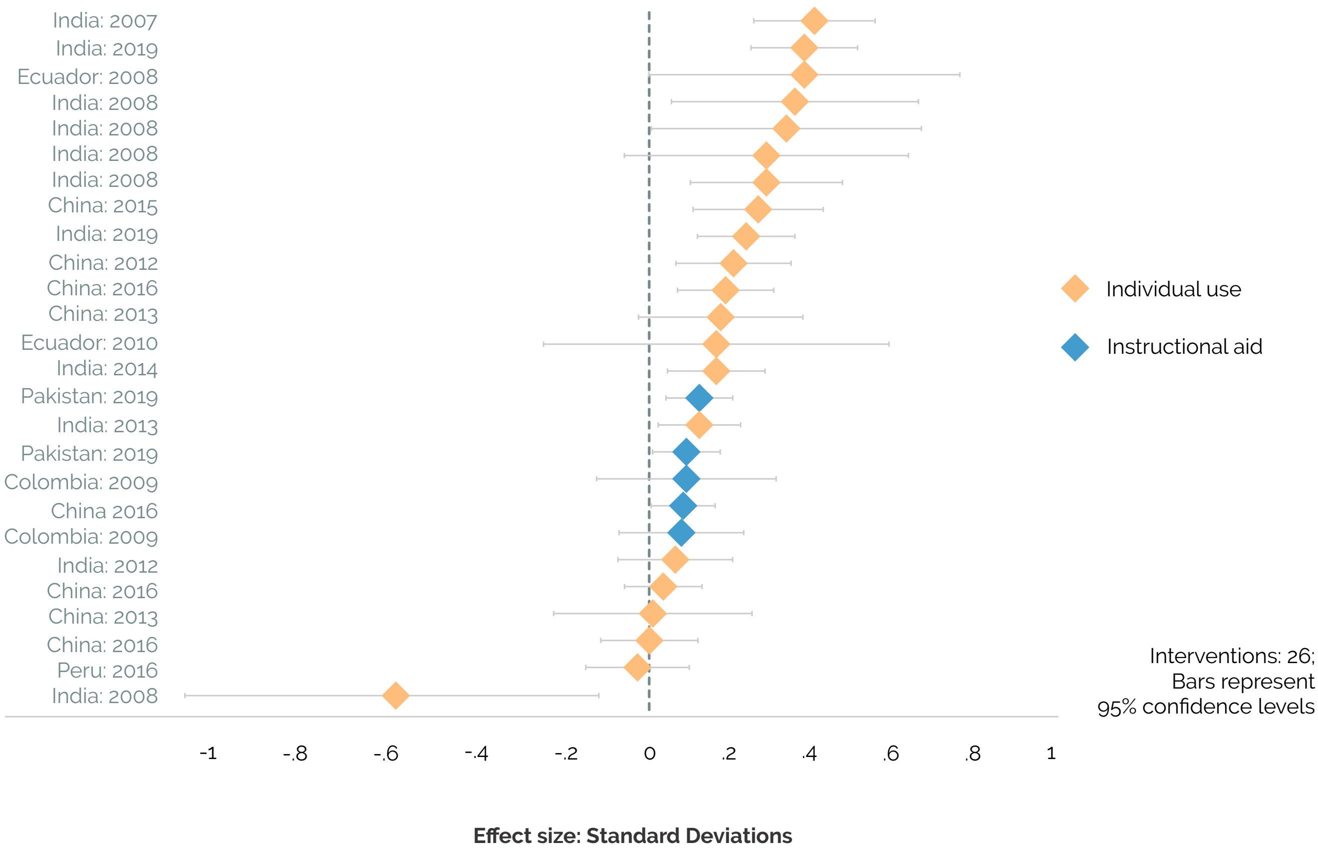


FIGURE 2: EFFECT SIZE OF INTERVENTIONS BY PRODUCT TYPE

[13] See Table of Reviewed Studies in Appendix 5 for more information on cost-per-student for the interventions reviewed here.

EXPOSURE LEVELS:
DOSAGE, INTENSITY, AND DURATION

Effect sizes from EdTech do not correlate with dosage (total hours of use), intensity (minutes used per week), or duration of use (total number of weeks). Figures 3, 4, and 5 show how, for the reviewed interventions, dosage and duration have no meaningful correlation with effect size. While intensity appears to have a slightly negative relation, this correlation is driven by a single large negative result.

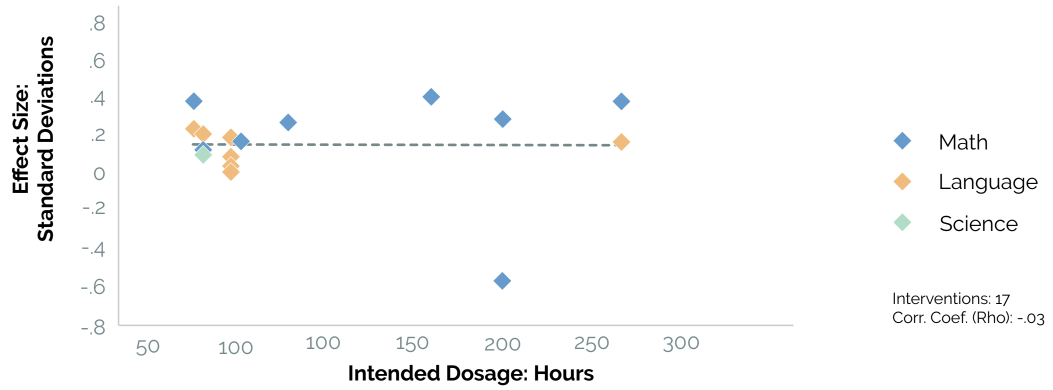


FIGURE 3: INTENDED DOSAGE (TOTAL) VS EFFECT SIZE[14]

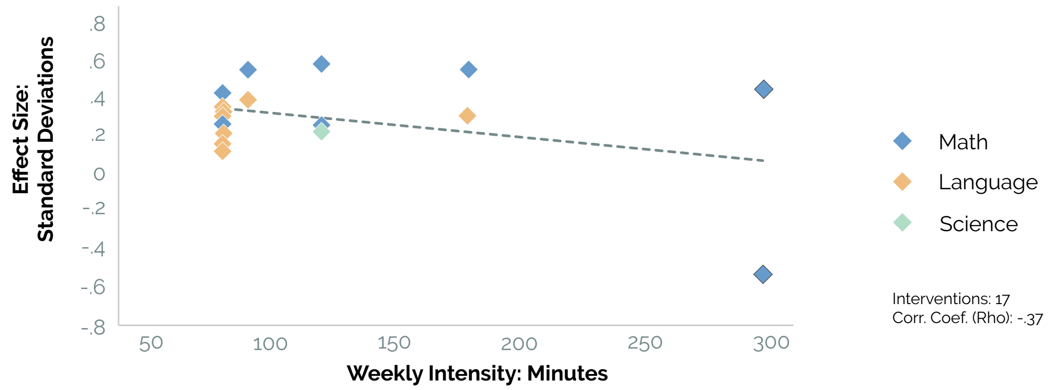


FIGURE 4: WEEKLY INTENSITY VS EFFECT SIZE[15]

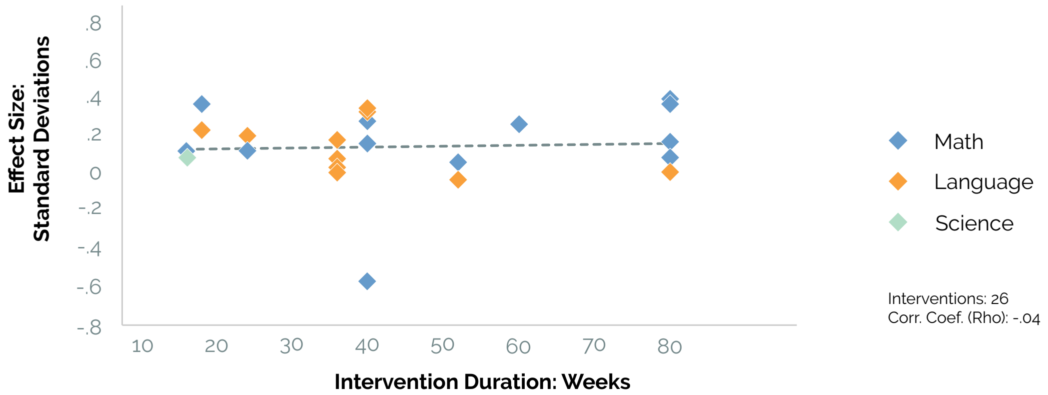


FIGURE 5: INTERVENTION DURATION VS EFFECT SIZE

[14][15] For 9 of the reviewed treatment arms, information on intended dosage was not available.

SCHEDULING: AFTER SCHOOL VS IN CLASS

School-based EdTech interventions may be implemented either during existing classes or after regular school hours. If implemented after school, EdTech typically leads to additional study time. For that reason, any effects are additive. However, if implemented during school hours, interventions may displace otherwise productive instruction time. Therefore, the effect of the intervention depends on the relative productivity of the intervention against the activity it is replacing. If the opportunity cost is high (i.e. it is replacing effective traditional instruction), then even useful EdTech interventions may have no or negative effect sizes as they are substituting for otherwise productive time.

Consistent with this hypothesis, evidence of in-school programs suggests the impact is higher when the status quo of education quality is low (e.g. in low-resourced municipal corporation schools) or unproductive (e.g. displacing underutilised "computer class periods"). The evidence suggests low or null impacts when the status quo education quality is high such as in high-resource NGO schools (Linden 2008).

SUBJECT-FOCUS: MATH AND LANGUAGE

Evidence suggests that EdTech can be effective at targeting both Math and Language competencies. Few studies existed for other subjects. As Figure 6 shows, interventions targeting both subjects have shown positive results. However, some evidence suggests EdTech may be relatively more effective for Math. Of the five reviewed studies comparing the effectiveness of the same intervention on Math and Language, two report larger effects for Math (Carrilo, Onofa, and Ponce 2011; Muralidharan, Singh, and Ganimian 2019), and three report no effect on either (Barrera-Osoria and Linden 2009; Cristia, et al. 2012; Mo, et al. 2013).

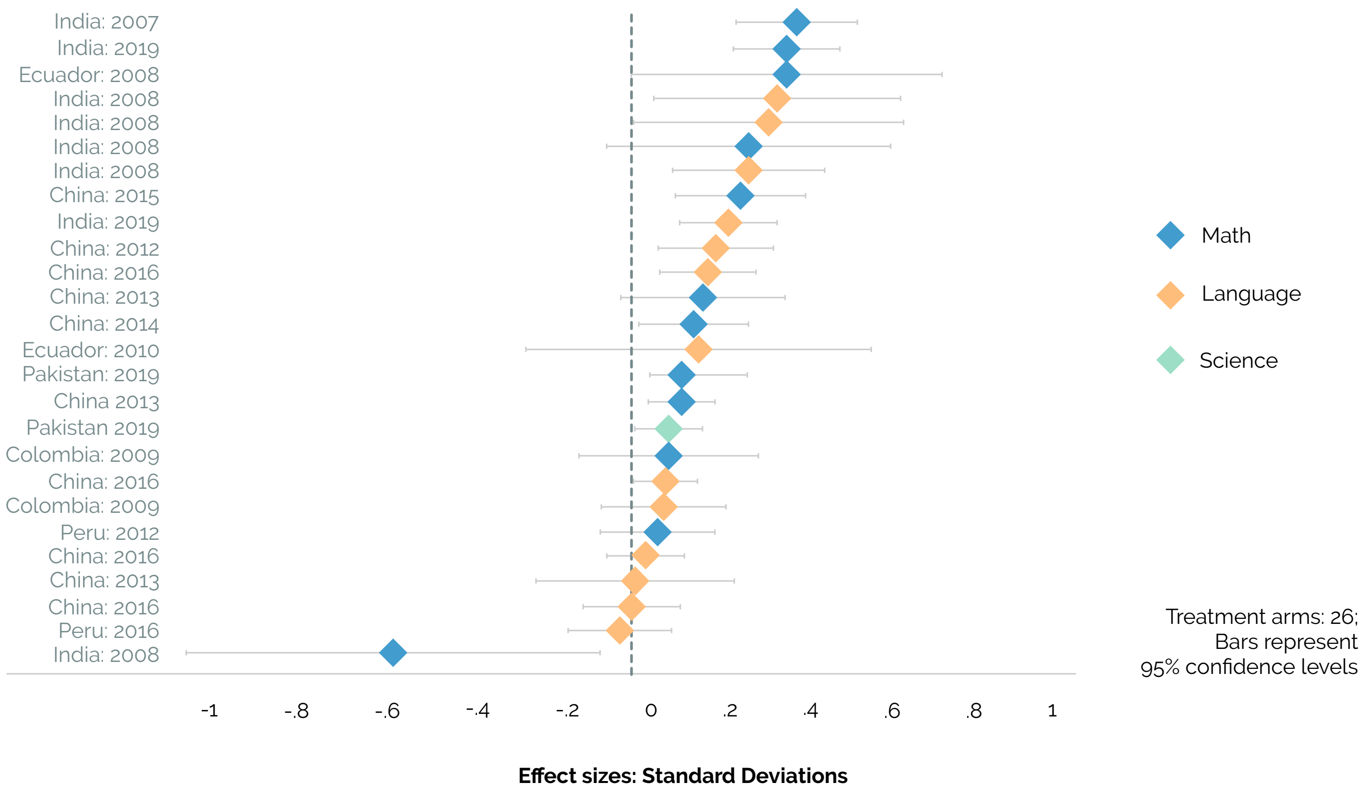


FIGURE 6: EFFECT SIZES BY SUBJECT

ADAPTIVITY

Interventions that leverage adaptive technologies to match instruction to the learning level of users have shown large positive effects. The three reviewed interventions with the largest effect sizes were those that used products with adaptive technologies (Figure 7).[16] This is consistent with other context-relevant research that shows large gains can be made generally by providing instruction aligned with student capability levels (Banerjee, et al. 2016).

While some have raised concerns that adaptive products could exacerbate existing learning inequalities, evidence shows adaptive interventions do not consistently benefit higher or lower-performing students more. Some studies show larger gains for higher-performing students (Carillo, Onofa and Ponce 2011). Some showed higher gains for lower-performing students (Banerjee, et al. 2007) (Muralidharan, Singh and Ganimian 2019).

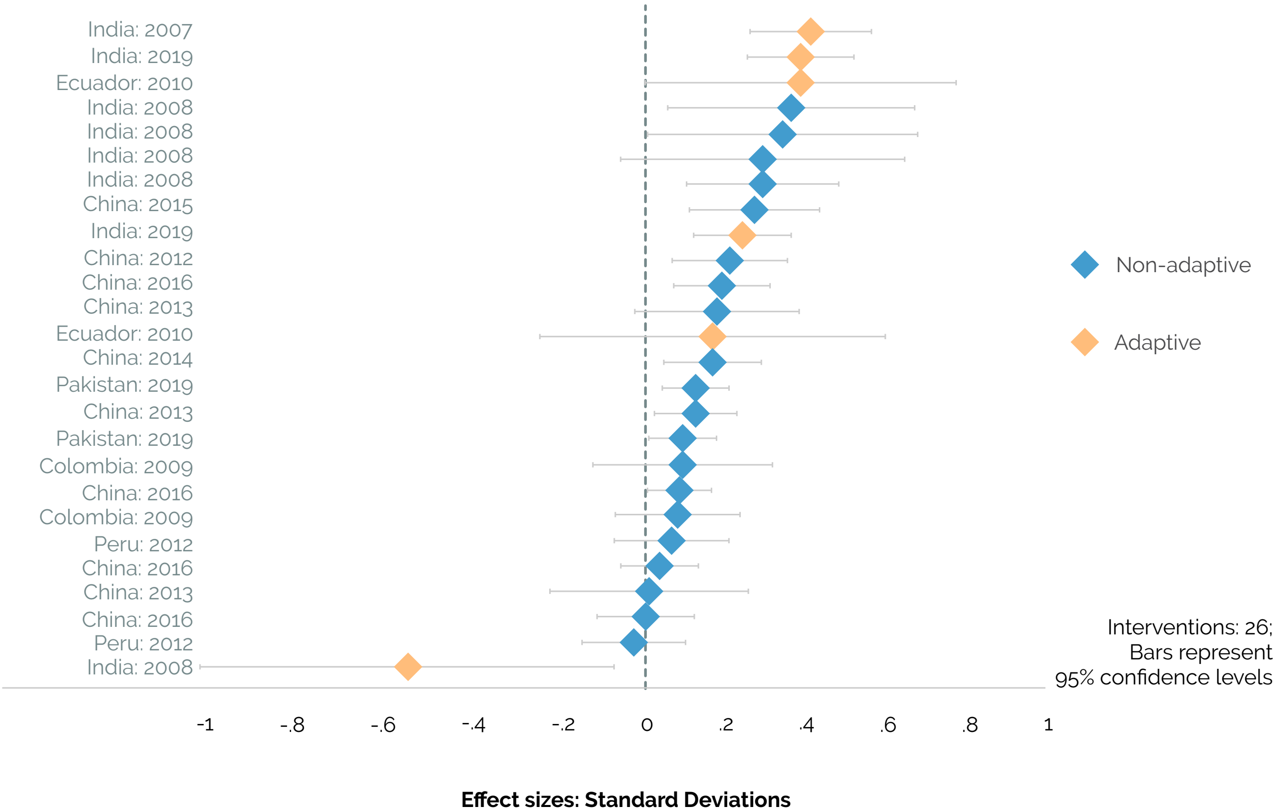


FIGURE 7: EFFECT SIZES BY ADAPTIVITY

[16] See Banerjee, et al. (2017), Carillo, Onofa and Ponce (2011), and Muralidharan, Singh, and Ganimian (2019).

4

OVERVIEW OF RAPID EVALUATIONS

OBJECTIVE

IDinsight conducted Rapid Evaluations on 12 high-potential EdTech products. The evaluations were designed to evaluate how well the products were functioning in their existing market and how appropriate they would be for scale-up in government schools. Each product was evaluated across five research categories:

Product Design:
Does the product design incorporate practices that appeal to students and support student learning?

Support:
Does the product maker provide adequate support and training?

Adoption:
Do schools and parents accept and encourage use? Would it be usable in a low-resource environment?

Engagement:
Do students actively use and engage with the product?

Learning:
Do school staff, students, and experts believe the product could lead to learning through sustained use?[17]

To answer these research questions the research team interviewed school staff and students and a panel of experts reviewed the products according to a predefined rubric. In addition, nine product companies shared backend Management Information System (MIS) data. Based on the combination of this data, products were scored on each research category on a three-point scale reflecting 'poor', 'satisfactory', and 'high' performance.

Figure 8 shows the distribution of products evaluated by product type.

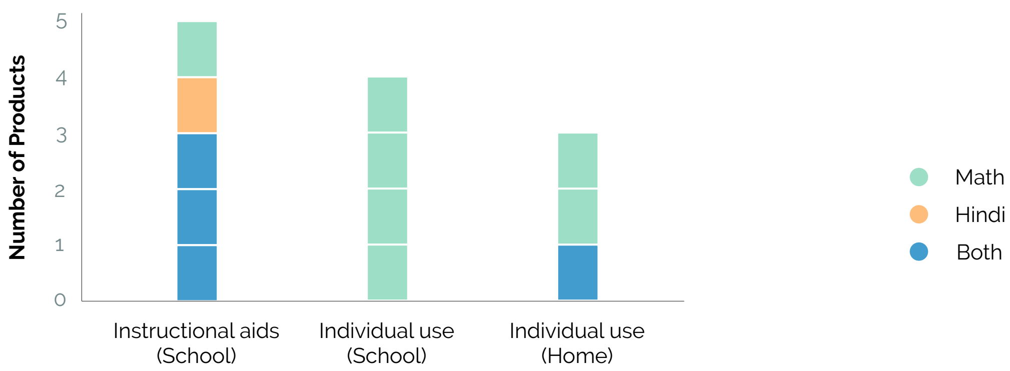


FIGURE 8: DISTRIBUTION OF PRODUCTS UNDER EDTECH LAB

[17] Data on learning outcomes were never measured as part of these evaluations. No statements can be made about the products' effect on learning.

DATA

In total, information was collected from over 1,600 school staff and students in 10 states. MIS data was collected for over 17,000 users and 3,900 schools. See Table 2 for a description of the total sample. Figure 9 shows the geographical distribution of schools that were visited.

Data Source	Instructional aids (School)	Individual-use (School)	Individual-use (Home)	Total
Number of evaluated products	5	4	3	12
Schools	27	17	NA	44
Teacher Interviews	60	29	NA	89
Administrator Interviews	24	8	NA	32
Classroom Observations	25	16	NA	41
Implementer Interviews	16	12	NA	28
Student Survey (Paper-and-Pencil)	693	288	NA	981
Student Interviews	60	49	401	510
Parent Interviews	N/A	N/A	26	26
MIS: Unique Users & Schools	3,907 (Schools)	6,865 (Students)	10,612 (Students)	
Expert Reviews	26	20	16	62

TABLE 2: TOTAL DATA SAMPLE[18]

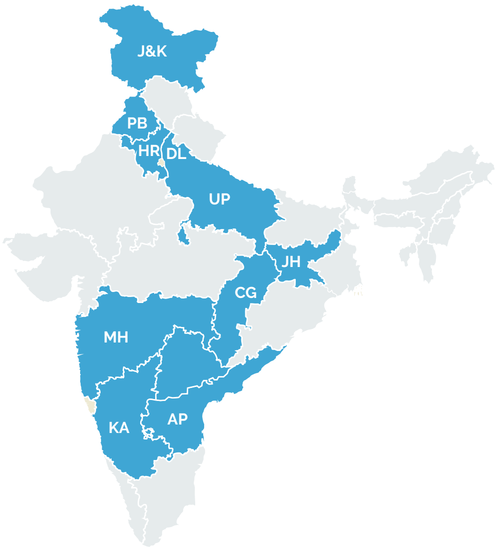


FIGURE 9: GEOGRAPHIC COVERAGE OF IN-PERSON SAMPLE

Sampled Schools		
Andhra Pradesh	AP	13
Delhi	DL	9
Uttar Pradesh	UP	6
Jammu & Kashmir	J&K	5
Karnataka	KA	3
Maharashtra	MH	3
Haryana	HR	2
Chattisgarh	CG	1
Jharkhand	JH	1
Punjab	PB	1

[18] Parents were not interviewed for school-based products and school-related school staff were not interviewed for home-based products. These are reflected by 'N/A'.

SCHOOL STAFF AND STUDENT INTERVIEWS

For each school-based product, research teams visited 3-5 schools to learn from user perceptions and experiences. Semi-structured interviews were conducted with 10-15 teachers, 3-5 administrators, 10-15 students, implementing partners where applicable, and education officials where applicable. Additionally, 100-150 students were administered paper-and-pencil surveys and 3-5 product use-sessions in classrooms were observed. Schools were sampled purposively, targeting variation in implementation factors such as rural or urban settings, varying use levels, and differences in implementation models.

For the 3 home-based products, research teams conducted phone interviews with 183, 154 and 64 students respectively and about 30 parents in total. The sampling process was different for each of the three products due to operational constraints. For one product, users were sampled purposively based on use behaviour. For another product, a random sample from the population of users was drawn. For another product, users were recruited through a product company process where only users who signed-up to be interviewed were called.

EXPERT REVIEWS

Each product was reviewed by 4-6 education and technology experts. They reviewed the product based on content, pedagogy, instructional design, user experience, and backend technology. Products were quantitatively scored against a 55-item review rubric. Experts additionally provided qualitative feedback against 17 rubric categories.

MIS DATA

MIS data was collected from product companies when possible. The data focussed on behaviour of students and teachers such as login frequency, questions attempted, resources accessed, and features accessed. This data was used to understand dosage, use trends, and use behaviour.

The MIS data sample for each product varied based on what data was tracked and whether the companies were able to transfer the data. All product companies who sent data did so for a use period of at least one school year. For user data, product companies either sent information on all users or a random sample of 2000 users. For school data, product companies sent information on all schools, except for two exceptions. In one case a product company sent data only for a random sample of 460 schools. This company was constrained by query times and file sizes. In another case, a product company only sent us data for the 25 schools that had up to date and accessible data. This data was not treated as representative.

Product companies were asked to provide a comprehensive dataset based on a pre-defined outline. However, the MIS data available for analysis differed for each product. Appendix 3 shows the spread of MIS data analysed across products and product types.

5

FINDINGS AND RECOMMENDATIONS

BASED ON RAPID EVALUATIONS

METHODOLOGY FOR GENERATING INSIGHTS

The Rapid Evaluations were designed to help CSF assess the potential of the 12 products for serving students from low-resource households and not to provide insight into the EdTech sector overall. However, since similar data were collected for a large number of promising products, larger themes could be extracted. The insights and recommendations that follow were developed by selecting the most prevalent and important themes that emerged across evaluations. In only a few cases, insights were generated from a single product evaluation. This was either because that insight was only relevant to one product or because the requisite data was only available for one product. The listed findings are not exhaustive.

In the following section, when MIS data are used, data is presented for **all products for which such data was available**, unless otherwise stated.

The major limitation of these evaluations is that they are based on small samples and are unable to say anything about the impact of these products on learning outcomes. The findings only indicate what appears to be positive or negative based on the three data sources, interviews of students and school staff, expert reviews, and MIS data.

PRODUCT DESIGN

The following is a list of the major **product design** insights that emerged from the Rapid Evaluations. The insights cover overall **product type, features, content, delivery, matching instruction with student learning levels**, and **use of data**. Each is followed by a recommendation.

OVERALL PRODUCT TYPE

No product type performed consistently better than the others. Overall performance depended on the details of the products' features and how it was implemented. Some products from the two major product types performed well against the Rapid Evaluation criteria and some performed poorly. Each product was given a rating against the five Rapid Evaluation research questions: adoption, engagement, learning, product design, and support. Figure 10 shows how product performance did not correlate with product type.

Selecting products based on type alone could lead to poor product selection.

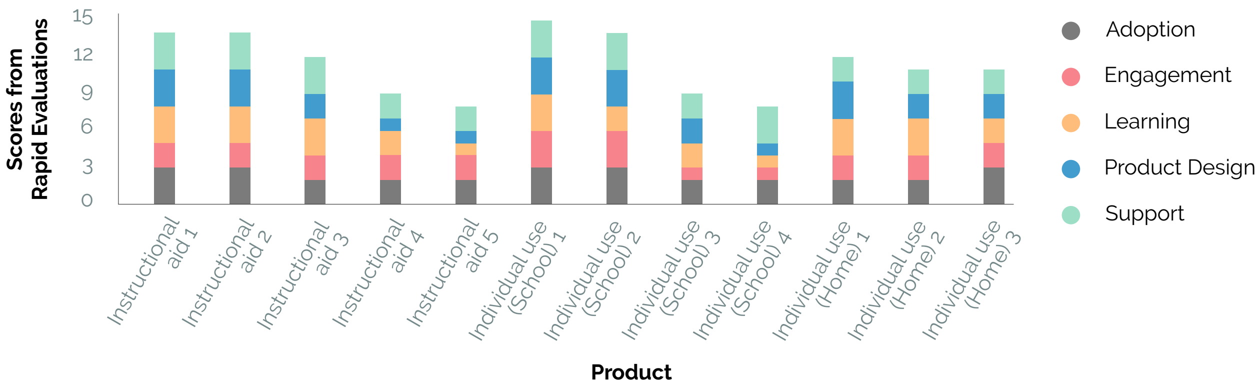


FIGURE 10: RATING OF EACH PRODUCT BY CATEGORY FOR EACH PRODUCT AND PRODUCT TYPE[19]

[19] Products that had N/A rating in research categories were given a score of 2/ on 3 for that category.

Product feature set did not clearly correlate with product performance. Figure 11 shows the overall performance of four products with similar features. All four products were individual-use products that offered content videos, practice questions, and assessments. Despite offering similar features, their performance in the Rapid Evaluations varied greatly.

Additionally, Figure 12 shows how use varied among these four products. It shows the number of sessions the average student logged over their first 24 weeks of use. One of these products had the highest use of all 12 products and one of them had the lowest. Despite similar features, use varied considerably.

Selecting products based only on **feature-set** could lead to poor product selection.

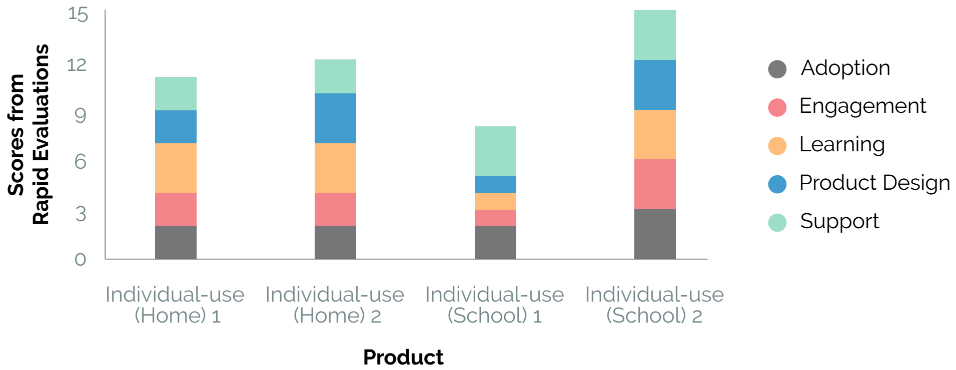


FIGURE 11: OVERALL PERFORMANCE OF FOUR PRODUCTS WITH SIMILAR FEATURES

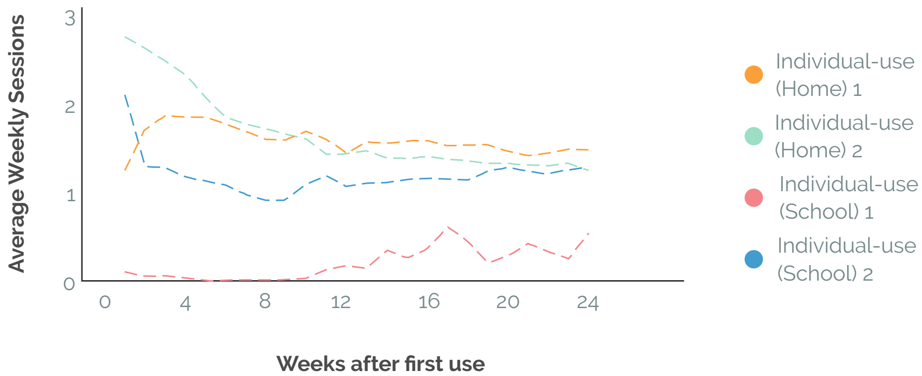


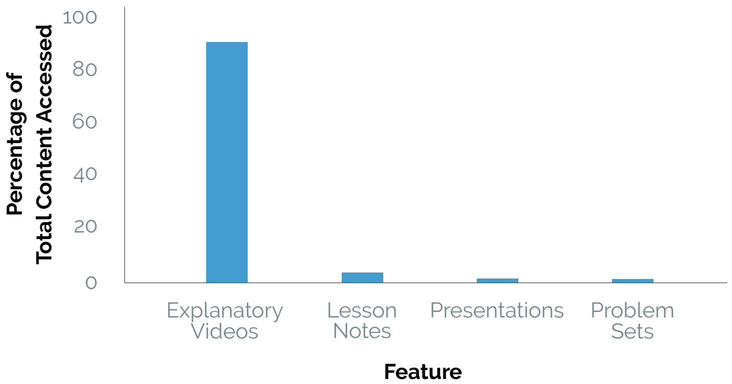
FIGURE 12: WEEKLY USE OF FOUR PRODUCTS WITH SIMILAR FEATURES

Recommendation: In addition to selecting products based on type and features, use targeted evaluation methodologies at various stages of roll-out to ensure the product is meeting its intended objectives. See the section on 'Suggestions for Implementers'.

FEATURES

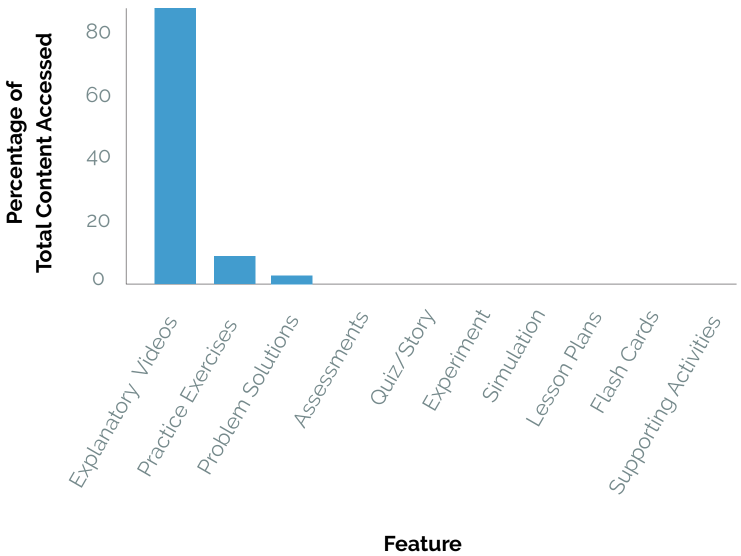
Instructional aid products were used almost exclusively for showing videos. Advanced features were rarely used.[20] Product makers and experts often said the products would be of low pedagogical value if they were used only to show videos. However, evidence from students, teachers, and classroom observations consistently showed that instructional aid products were mostly used for videos.

Advanced features, such as practice problems, pre-designed assessments or simulations were rarely used. Figure 13 & Figure 14 show the percentage distribution of features accessed for two instructional aid products - explanatory videos accounted for 90% of the features accessed for both products. Additionally, Figure 14 shows that teachers mostly used only three features despite being offered a range of options. Supporting these findings, one teacher, commenting on their product use, said, "I do not need a lot of skills on [the product]. I just open up videos."



N - 2530 Schools
Note: Teacher-level data was not available

FIGURE 13: USE OF PRODUCT FEATURES IN ONE INSTRUCTIONAL AID PRODUCT



N - 4602 Teachers; 436 Schools

FIGURE 14: USE OF PRODUCT FEATURES IN A SECOND INSTRUCTIONAL AID PRODUCT

[20] Importantly, simple inclusion of quality digital content may accelerate learning (Beg, et al. 2019).

Recommendation: Instructional aid products should have high-quality explanation videos as products are mostly used to show these videos.

Use of videos was also high in individual-use products. In one product which experts said had high-quality practice questions and mediocre videos, videos were still the most commonly used feature (Figure 15). In one school-based product, videos were used more than stories, books, and games (Figure 16).

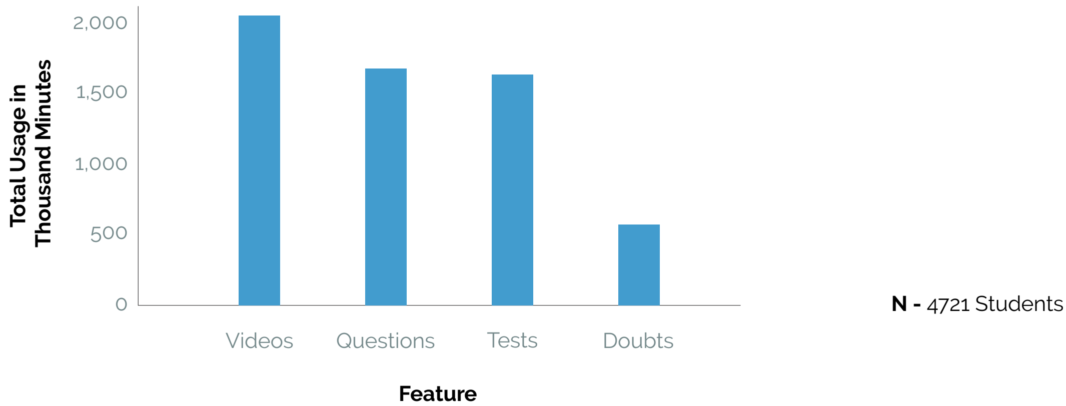


FIGURE 15: MOST ACCESSED FEATURES FOR ONE INDIVIDUAL-USE PRODUCT

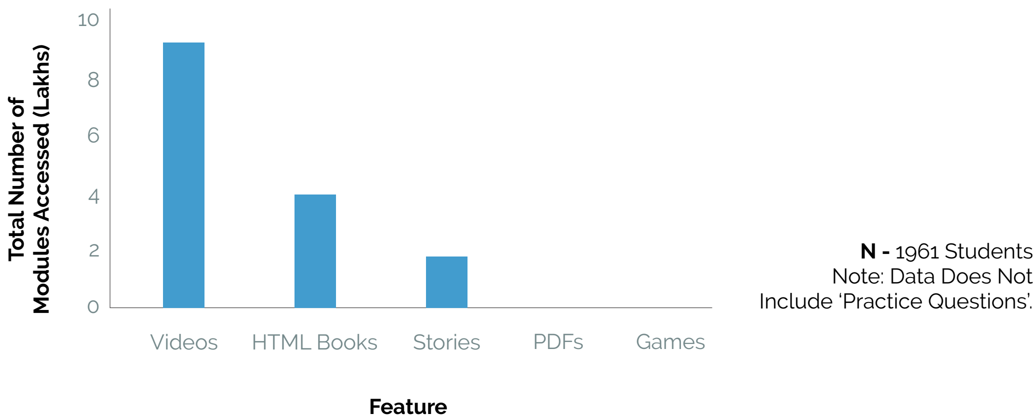


FIGURE 16: MOST ACCESSED FEATURES FOR A SECOND INDIVIDUAL-USE PRODUCT

Two of the home-use products provided users a wide variety of features. Nonetheless, students using both products most commonly said they like instructional videos more than other features (Figure 17).

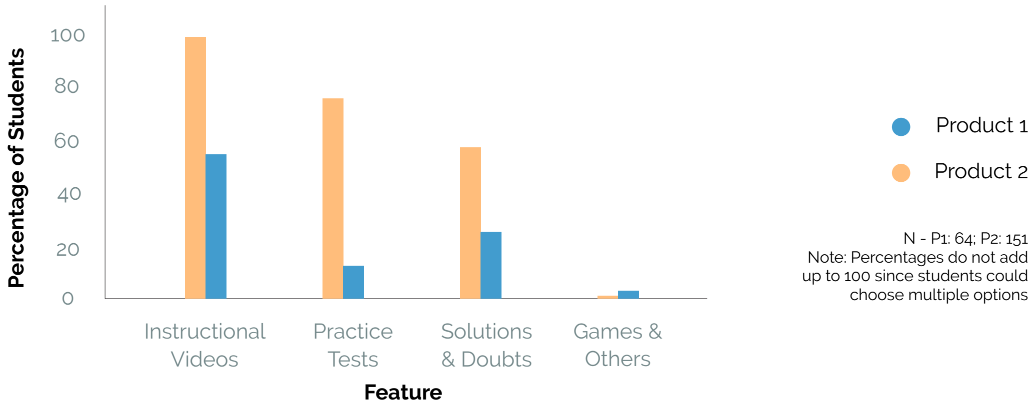


FIGURE 17: MOST COMMONLY LIKED FEATURES FOR TWO INDIVIDUAL-USE PRODUCTS

Recommendation: If interactive features are an important component of the pedagogical strategy to improve learning, individual-use products should actively steer users towards these features.

High quality lesson plans appeared to reduce teacher workload. Teachers using two products with quality lesson plans said they reduced workload. Teachers did not complain about reduced flexibility in designing or personalising their lessons. Delivering high-quality lesson plans may alone improve learning outcomes. A recent meta-analysis of teachers' guides across 13 countries found that providing teachers' guides leads to substantial and meaningful impact on learning (Piper, et al. 2018).

Recommendation: Instructional aids should provide lesson plans that are thorough, flexible, and make integration of the product with standard classroom practices easy.

CONTENT

Most Hindi-language content was low quality. Despite focusing on Hindi language as a primary focus of EdTech Lab, few products were found that offered Hindi content. Of the five that were found and evaluated, teachers and experts said that most of them had poor quality content. Only one product was rated favourably. Experts said that much of the Hindi content was limited to reproductions of passages from textbooks read by a narrator, often with no modulation or engaging vocal quality. Additionally, experts and teachers were much more likely to note spelling and pronunciation errors in Hindi-language learning sections than in other subjects. One expert speculated that at times Hindi content was added merely to complete the full course offering and thus increase marketability.

Recommendation: Vernacular-language learning products should incorporate quality pedagogical practices and use more engaging content than merely passages of textbooks read aloud.

Poor curriculum mapping (organising and labelling content by how it fits with the syllabus) was a major barrier to consistent use. For products that had poor curriculum mapping, teachers reported difficulty in both navigating the content as well as being able to use the product consistently in class. They reported that these products increased their workload. Students who used products at home also complained when they could not easily find curriculum-aligned content.

Recommendation: Features and content should be clearly and accurately mapped to the school curriculum. The product navigation and content structure should enable users to easily integrate the products into regular instruction practices.

Sufficient content coverage of every sub-topic within a subject helped students and teachers dependably use products. When the product's content covered only part of the school curriculum, teachers complained that using the product consistently was difficult. They said they could not depend on finding useful content. While some instructional aid products allowed teachers to augment pre-loaded content with their own content, few teachers said they did so. When individual-use products had too little content for a topic, students complained that they did not have enough options for understanding concepts.

Figure 18 shows content used for three products (the only ones which provided sufficient data for this assessment). Subject-wise use was proportional to subject-wise availability of material. Products generally had more content available for Science and Math, which were also the subjects used most. Hindi content was often a small fraction of the content available and correspondingly use was also low.

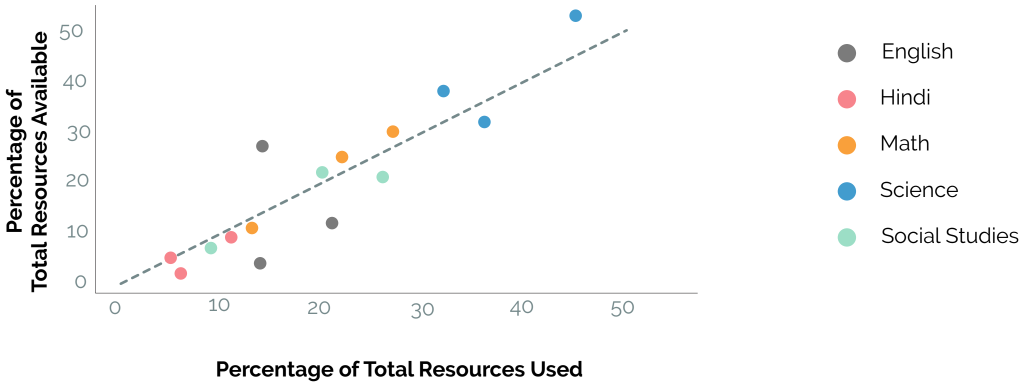


FIGURE 18: CONTENT AVAILABLE VS CONTENT USED FOR THREE PRODUCTS[21]

Recommendation: Products should provide comprehensive coverage of all target subjects.

DELIVERY

Students struggled to use products if the language of content or instruction was not in students' native languages. Despite this, many implementers used non-native language instruction. For one school-based individual-use product, nearly all teachers cited English as a barrier to students' comprehension of the content. In the case of one instructional aid, teachers said they often had to stop and explain unfamiliar English words and expressions. For home-based products, students said they relied on parents to explain unfamiliar language or skipped parts they did not understand. Furthermore, a large body of evidence shows that primary school students are most effectively taught in a language that they are fluent in (Fergusson, 2013).

Recommendation: Use native language content and interface.

For a few individual-use products, students struggled to follow written instructions which made it difficult for them to use the product meaningfully. Experts and users of a few products complained

[21] For the 2 instructional aid products included here, the data relates to overall use across all features. For the 1 individual-use product included, the data relates to question attempts (the only data component which allowed such assessment).

that they relied too heavily on text instructions and explanations, which according to the experts, could discourage students, especially younger ones. Users of one product said they would prefer more animations instead of text. Reliance on written text could be a problem for the large number of students who struggle with basic literacy, though few such students were interviewed for this study, given the approach of talking to existing users.

Recommendation: Instructional language should be accessible to a wide range of capability levels. Products should minimize the need to follow written instructions, especially for younger grades. They should use simple interfaces, little text, and audio cues.

Some products used unfamiliar examples and Western names or accents. Teachers and experts said accents used in voice-overs were sometimes foreign or difficult to understand for students. Western names for people and places were sometimes used. Such examples were most often not understandable to rural students. For example, one product referenced avocados (which are not well known in all parts of the country) which the teacher said distracted the class from the lesson.

Recommendation: Content should use language, references, and examples that are understandable to students in the implementation context.

MATCHING INSTRUCTION WITH STUDENT LEARNING LEVELS

Teachers use content from multiple grade levels within a single class. As an example, teachers using one individual-use product in classes said they assigned lower grade content to students to develop their competencies before moving on to grade-level content. MIS data from instructional aid products showed that in 10%-20% of sessions, teachers used content from more than one grade (Figure 19).

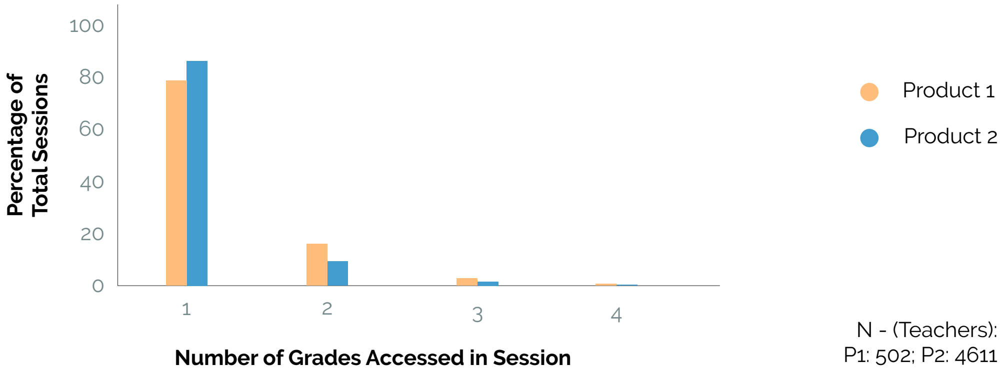


FIGURE 19: NUMBER OF GRADE-LEVELS ACCESSED IN A SESSION FOR TWO INSTRUCTIONAL AID PRODUCTS

Students use content from multiple grade levels. One home-based individual-use product limited content for users to a single grade. However, MIS data showed that the questions students asked in the question feature were usually below their assigned grade-level indicating that restricting their access to a single grade was likely inhibiting their access to capability-aligned content (Figure 20). MIS data comparing the grade of the user with the grade of the content was not available for other products.

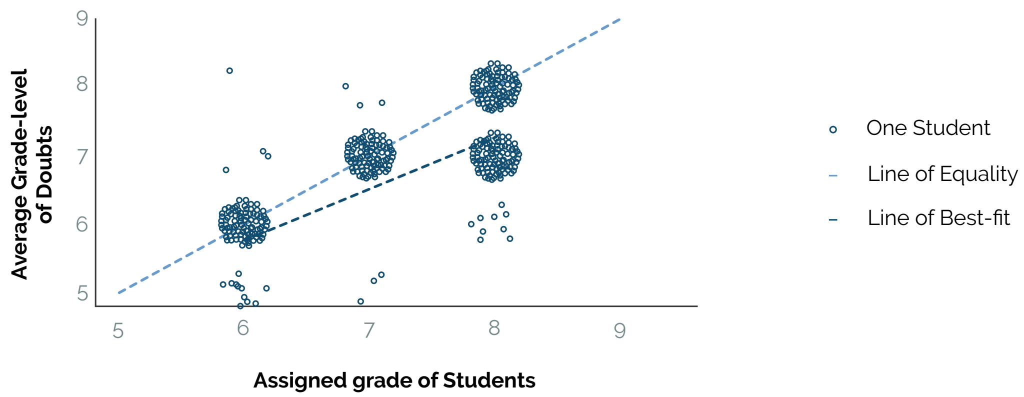


FIGURE 20: GRADE-LEVEL OF DOUBTS POSTED VS ASSIGNED GRADE

Recommendation: Products should allow students and teachers to access content across a wide range of difficulties and grade levels for all product types.

Adaptivity Definitions[22]

Within-topic adaptivity:
adjusting the difficulty or changing the number of questions in a topic based on students' performance in that topic.

Across-topic adaptivity:
determining which topics students should study based on ongoing in-app performance assessment.

Few products administered assessments or used student performance data (adaptivity) to match instruction to the learning level of students. Only one product incorporated across-topic adaptivity and only two incorporated within-topic adaptivity. No products used pre-tests or other screening devices. This is despite the fact that CSF heavily emphasised adaptivity in the product selection process due to the evidence suggesting that adaptivity may be a strong predictor of effectiveness.

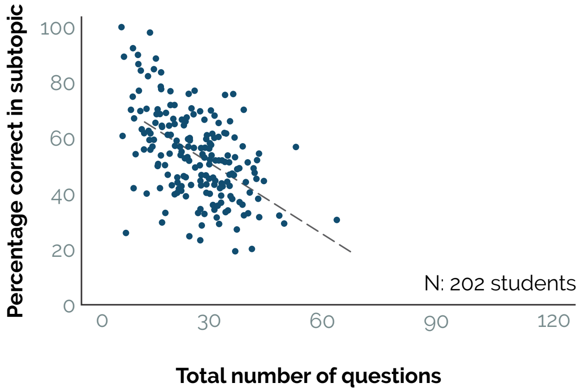
In products that use within-topic adaptivity, students who perform well in a subtopic should answer fewer total questions within that subtopic. The algorithm should send them to advanced topics more quickly. To test for this, the three most commonly answered subtopics by grade 6 students were analysed.[23] Figure 21 shows the relationship between student performance and total number of questions attempted for these three subtopics for four products.[24] A negative relationship suggests the products are adapting to student capability levels. The three rows represent the three most common subtopics per product. The products in the first set show evidence of adaptivity. The products in the next set do not. These trends were seen to hold for all grades that the products catered to.

[22] Definitions borrowed and adapted from Clark (2019).
[23] 'Most common' was defined in terms of number of unique attempts of questions tagged to that subtopic.
[24] The fourth product did not have grade 6 users and hence the closest grade, 5, was used.

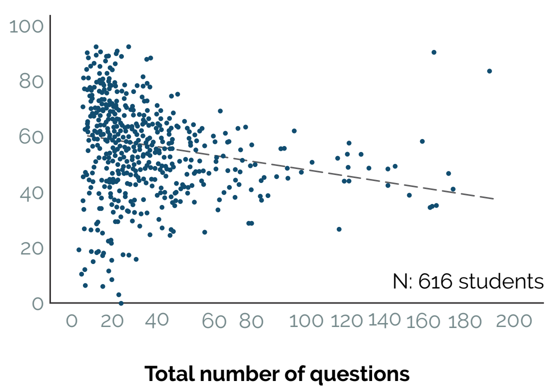
Adaptive

Product 1	Product 2

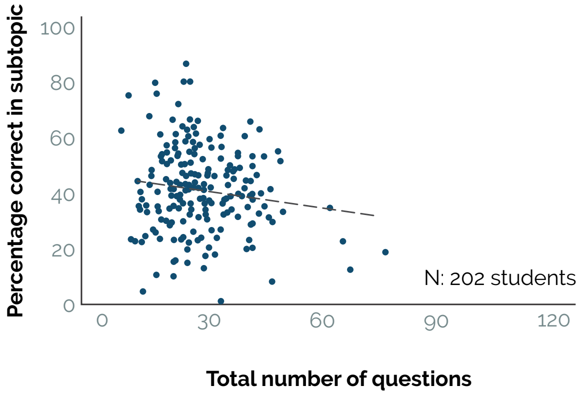
Grade 6; Subtopic 1



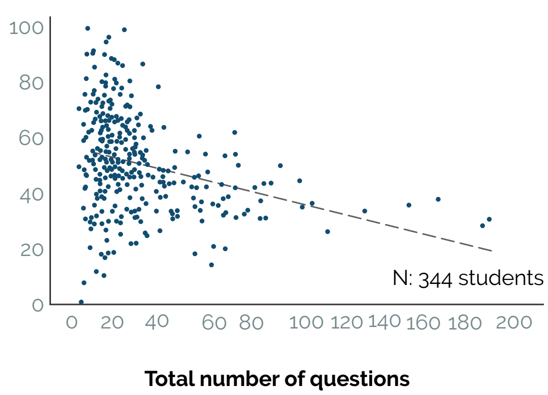
Grade 6; Subtopic 1



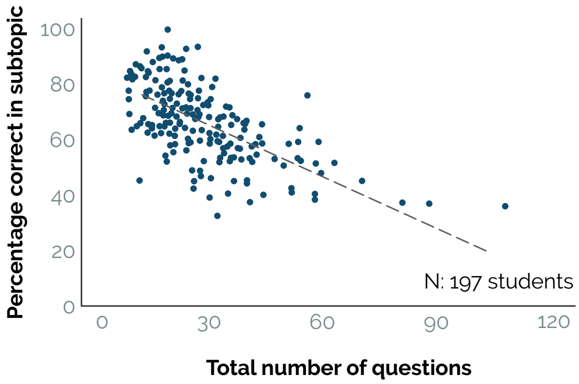
Grade 6; Subtopic 2



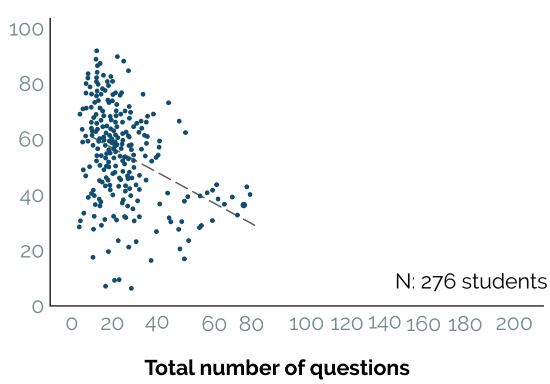
Grade 6; Subtopic 2



Grade 6; Subtopic 3



Grade 6; Subtopic 3



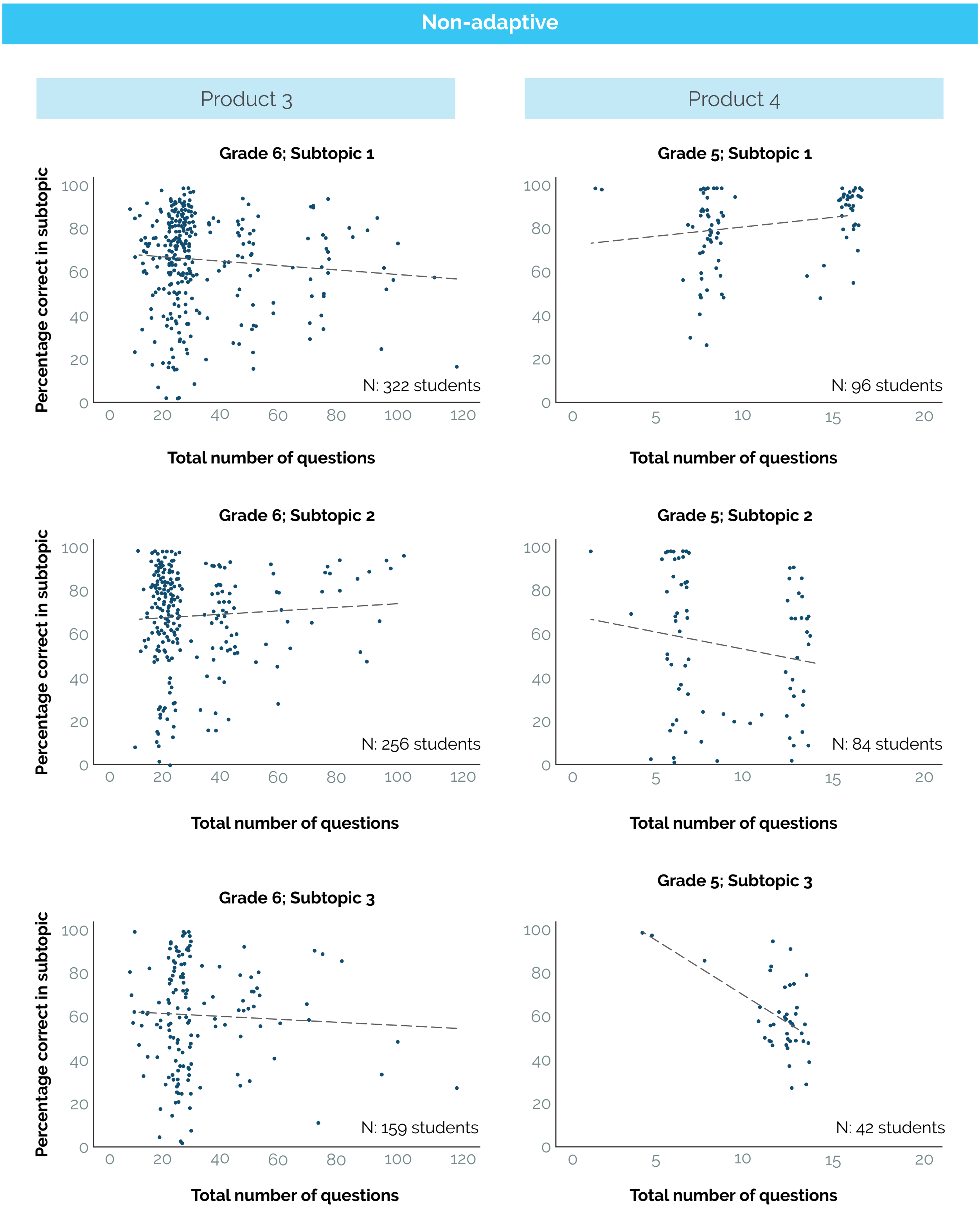


FIGURE 21: EVIDENCE ON ADAPTIVITY FOR FOUR INDIVIDUAL-USE PRODUCTS[25]

[25] The level and granularity of mapping on questions varied across products based on the inherent product structure and the underlying algorithms. For these graphs, data is presented at the 'sub-topic' level, which refers to the most granular-mapping of learning objectives that the products provided.

Recommendation: Individual-use products should use tools to match instruction levels with student capability.

Simple pre-tests could at least start students at the right level content. Additionally, advanced adaptivity could dynamically change the pace and order of the content to align with individual capabilities. However, features that move students away from the syllabus may be more difficult to implement in classrooms where teachers face pressure to complete their syllabus.

USE OF DATA

Product data could not be used to track overall student learning levels. A potential benefit of individual-use products is that they may be used to gather granular data on students' learning levels over time and across schools (MHRD 2018). Yet, while most individual-use EdTech products administered questions to students, none of the data from any of the products could be used to estimate overall student learning levels or to perform any comparisons of learning levels over time. The main obstacle was that none of the products (barring one) administered tests at regular intervals. The data from the one product that did test students at regular intervals could not be used to monitor learning over time because of issues with how the tests were constructed.

Recommendation: Products should build in credible assessments of learning gains over time.

Teacher dashboards were overly complex, contained too many features, and were hard to navigate. Several products included dashboards which allowed teachers to monitor student progress. However, teachers rarely used them. They complained that they were complicated and contained too much information which made them hard to use.

Recommendation: Dashboards for teachers should be simple and limited. They should provide practical, actionable insights. They could have basic information on student performance over time. Additionally, they could have features that allow teachers to monitor student performance in real-time during lab sessions.

IMPLEMENTATION

The following is a list of the major **implementation** insights that emerged from the Rapid Evaluations. The insights cover **technical support**, **training**, and **monitoring**. Each is followed by a recommendation.

TECHNICAL SUPPORT

Continuous help from full-time on-site support personnel (often called school coordinators) or on-call product company support was critical to sustaining use. In many schools, teachers required frequent help to set up the product, navigate to the right content, use various features, get the audio to function, and deal with software glitches or hangs. Teachers and headmasters offered many anecdotes illustrating the importance of ongoing support. One teacher mentioned reaching out to the product company for help on a near daily basis. In some schools, teachers said they would not even attempt to use the product when the on-site support person was absent. One headmaster said on-going support was more important than initial training for teachers.

Recommendation: Schools should have at least one on-site support person who is accessible and capable of troubleshooting basic issues.

On-site support personnel in multiple schools and across products were asked to solve the same small issues repeatedly. They reported that most problems they helped solve were simple issues such as help turning on the products and navigating to basic screens. Even students helped with this type of troubleshooting at times. During classroom observations some students were observed helping teachers with basic tasks such as setting up the product.

Recommendation: In addition to solving problems for teachers, support personnel should train teachers to perform basic troubleshooting.

TRAINING

Most introductory training was enough for teachers to start using the basic features of a product. Training often emphasised a range of skills including hardware use, software set-up, product navigation, how to integrate the product into classrooms, why the product could help students learn, how to sync the product, how to generate reports, and how to use advanced features. A few teachers commented that the hands-on sessions were the most helpful parts. Training for one product was limited to a quick navigation walkthrough which teachers felt was insufficient.

Recommendation: Provide teacher training that emphasizes hands-on start-up, navigation, and use of basic features, as well as how the product relates to the curriculum. Content should be tailored to teachers' existing comfort with technology. Training on individual-use products should include hands-on use of student features in addition to teacher features.

Standalone training without refresher training appears insufficient to maintain regular use.[26] Teachers using four different products specifically mentioned refresher training was helpful. One teacher noted that it helped with their comfort levels and understanding of how to integrate the product in classes. A few teachers who were never given refresher training requested them.

Additionally, teachers using two products requested written materials to use as a continued reference. One teacher noted that as time had passed since her initial training, she was anxious that she had forgotten some of the product features.

Recommendation: Provide a few refresher trainings per school year. Collect information on the most relevant knowledge gaps from teachers, administrators, and school coordinators to develop training activities.

Recommendation: Provide teachers with written training manuals that they can keep after in-person training ends.

In the absence of on-site company support, some companies trained local teachers to help others with minor issues. Two implementers used a 'nodal teacher' support model where one teacher was trained to provide on-site support to the rest of the school. In both cases the model seemed to do well to provide basic troubleshooting support to teachers, even though nodal teachers sometimes needed to contact others to resolve problems. However, nodal teachers were not good at giving introductory training to other teachers. Most teachers trained formally by nodal teachers felt that their training was insufficient.

[26] Evidence from other teacher training programs in low and medium-income countries shows that regular training is important for producing meaningful changes (Popova, Evans, & Aranciba, 2016; World Bank, 2018).

Recommendation: If a full-time on-site support person is not available, provide additional training to a nodal teacher who could then provide on-site support.

Recommendation: Avoid cascading training models. Nodal teachers should not be used to deliver introductory training to other teachers.

MONITORING

Active monitoring by administrators and on-site support personnel was correlated with higher product use. Some headmasters monitored use through periodically observing classes in person. Other headmasters regularly viewed product dashboards and discussed the use patterns they saw with teachers. One headmaster designed a competition among teachers to incentivize creative ways to use the product. However, some evidence showed that monitoring could incentivize gaming of metrics. In one implementation model, teachers reported that some teachers would merely turn on the products without using them to increase the levels of use shown on the dashboard.

Recommendation: Administrators and on-site support personnel should regularly monitor meaningful use of the product.

Recommendation: Use-monitoring should measure and report actual levels of use, including downtime. It should include data for products that are never used or used rarely.

Incorporating targets into monitoring of product use seemed to be a highly effective way to increase use in one implementation model. For this product, education officials and headmasters would closely track use against targets through a dashboard. Education officials would discuss and flag poor performing schools to headmasters. Headmasters regularly called, texted, or met with teachers who had low product use.

Recommendation: Schools could use targets to incentivize use. However, they should have a high degree of confidence in the efficacy of a product before incentivising use.

Recommendation: Targets should not be gameable to the extent possible. Use-targets should be carefully constructed to ensure that they incentivize meaningful use and not just focus on the amount of time the product is turned on.

OVERALL RECOMMENDATIONS

The set of features and implementation choices for the products evaluated under EdTech Lab did not predict their overall quality. The effectiveness of an EdTech product will depend on each product's unique combination and quality of features, the quality of implementation execution, and a host of parameters unique to each local context. Given this important caveat, the following examples describe features and implementation choices that appear promising based on analysis of features and implementation models of products studied in Stage I of the EdTech Lab:

PRODUCT FEATURES

A **technology-aided instruction** product that has:

01 Thorough lesson plans that integrate product features with standard curriculum.

02 Detailed and accurate curriculum-mapping.

03 High-quality digital content with thorough concept explanations for every subtopic.

04 A few easy-to-use interactive features such as discussion prompts and activities.

05 All content and navigation in the local first language.

An **individual-use product** that has:

01 Tools that match instruction to the learning level of students.

02 Intuitive visual and audio-based navigation.

03 Well-made questions with useful hints and feedback on missed questions.

04 Thorough concept explanations that are directly linked from questions.

05 All content and navigation in the local first language.

IMPLEMENTATION MODEL

An **implementation model** that has:

01 Training that is comprehensive, direct, and hands-on for each teacher with refresher trainings every three months.

02 Extensive training for an on-site nodal teacher that can provide basic troubleshooting and navigation support to other teachers in the school.

03 Timely on-call support for more difficult issues.

04 Monitoring by administration and/or education officials that includes tracking indicators of meaningful product use and regularly communicating with teachers.

6

FUTURE OPPORTUNITIES

In addition to findings about EdTech products based on direct research activities, the initial stages of the EdTech Lab generated insights relevant to the larger ecosystem. The following section gives recommendations to funders, product companies, researchers, and implementers based on these insights.

Gaps in the marketplace highlights which types of products are most lacking in the current market. These were identified by combining the gaps identified in the landscaping exercise with the most important product features identified in the Rapid Evaluations. These recommendations are meant for funders and product companies.

Gaps in the evidence base highlights research priorities. These priorities are based on the combination of gaps identified in the review of rigorous research as well as the most pressing questions that arose from the Rapid Evaluations exercise. These recommendations are meant for researchers.

Strategies for evaluating products gives recommendations on what evaluation strategies to use when implementing an EdTech product. These recommendations combine insights from running the Rapid Evaluations, insights from working with implementers currently using EdTech, and lessons from running other evaluations of education interventions. These recommendations are meant for implementers.

GAPS IN THE MARKETPLACE: OPPORTUNITIES FOR FUNDERS AND PRODUCT COMPANIES

This section highlights which types of products are most lacking in the current market. These were identified by combining the gaps identified in the landscaping exercise with the most important product features identified in the Rapid Evaluations. These recommendations are meant for funders and product companies.

Few products have high quality instruction or content in languages other than English. Research shows that children learn more rapidly when taught in their first language (Fergusson 2013). However, few products use vernacular languages as the medium of instruction or have vernacular-language learning content. Furthermore, evidence from the Rapid Evaluations shows that vernacular-language learning content is often much lower quality than other content. Thus, products in which all navigation and content is in vernacular are highly needed.

Figure 22 shows the most common first languages in India. Big gaps in the market could be filled by developing high-quality products in major languages such as Hindi, Bengali, Telugu, Tamil and others. By contrast, though many English-language products exist, only a tiny fraction of the Indian population (0.02%) speaks English as a first language.

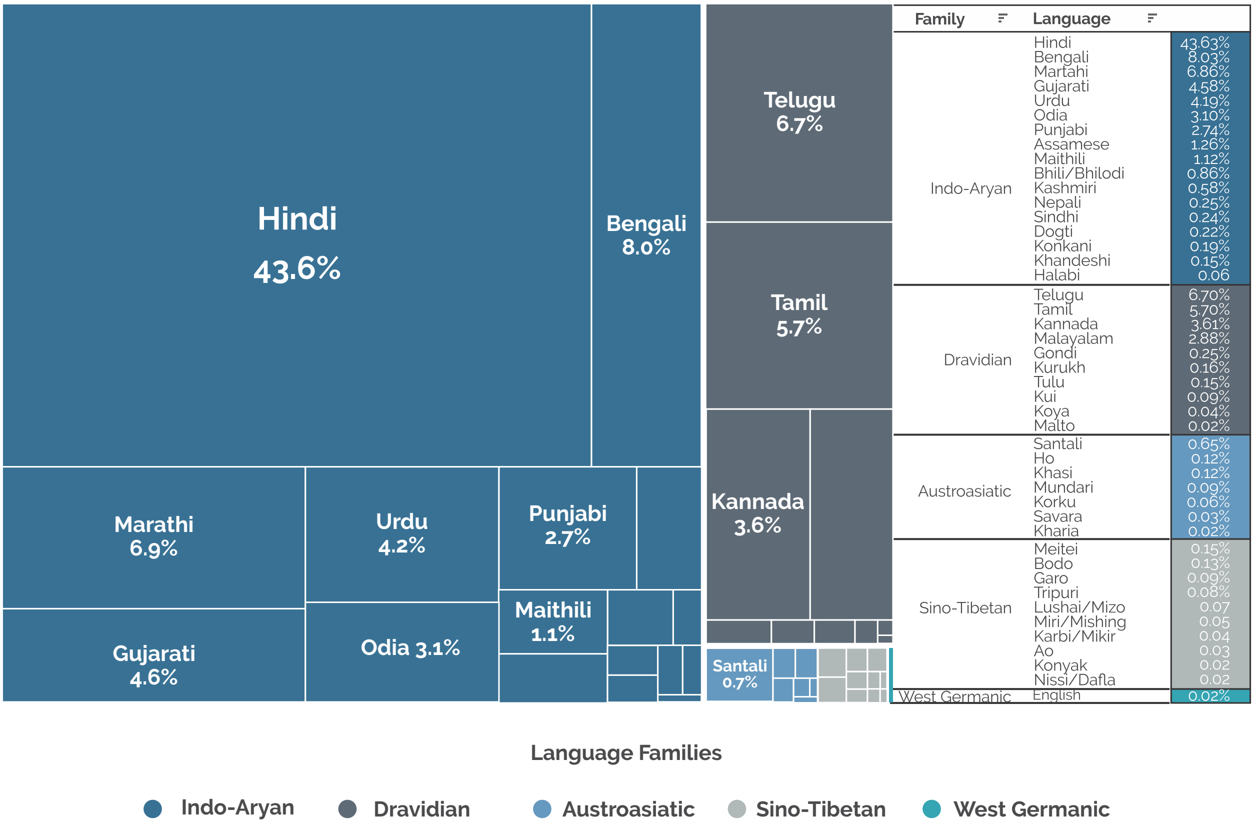


FIGURE 22: TREE MAP OF 45 MOST FREQUENTLY SPOKEN FIRST LANGUAGES[27]

Few products target instruction to student capability levels. The ability to target instruction to student capability levels, especially by using adaptive technology, was a major factor in selection for the EdTech Lab. Despite this, few products used adaptive elements or target instruction to student capability levels in any way. Additionally, some products did not allow access to lower-grade materials which prevented students from even self-selecting capability-aligned content. More products are needed that align content with student capability.

Few home-use products are affordable for low and medium-income households. The average price of the top-funded products on the market is ₹ 20,000 per year.[28] This is well beyond reach for most families.

[27] Based on Census 2011 (Abstract of Speakers' Strength of Languages and Mother Tongues)).
[28] Based on internal analysis conducted by CSF.

GAPS IN THE EVIDENCE BASE: OPPORTUNITIES FOR RESEARCHERS

This section highlights research priorities. These priorities are based on the combination of gaps identified in the review of rigorous research as well as the most pressing questions that arose from the Rapid Evaluations exercise. These recommendations are meant for researchers.

Can EdTech products improve learning when used at scale in government school systems? EdTech has shown that it can improve learning in many contexts. However, government education systems have unique conditions that may alter the ability of EdTech to improve learning outcomes. They include systems-level considerations such as if or how system incentives are aligned with the objectives of the intervention.[29] These also include school-level factors such as teacher capability levels, student capability levels, integration with timetable number and quality of devices and access to electricity and internet. Understanding if EdTech interventions can work in this context is important for governments considering such an investment. Further, governments would benefit from understanding what product types, implementation models, and system-level structures are best-suited to improving learning outcomes when using EdTech.

Which pedagogical features are the most effective? Beyond targeting instruction to student learning levels, which is backed by numerous EdTech and general education studies, too little is known about which pedagogical features are most important. Understanding which features most increase learning will help product-makers develop better products and will help implementers select better products.

Which products are the most cost-effective for in-school interventions? Estimates suggest individual-use products may be two to ten times more expensive than instructional aid products on a per-pupil basis. [30] However, they also have more broad evidence of improving student learning. Understanding the cost-effectiveness trade-offs of these product types, and how this varies by features, grade, subject, and other factors, will be critical to guiding procurement decisions for school systems with limited resources.

What degree of matching instruction to the learning level of students is most appropriate for individual-use products used in classrooms? Some products follow a single path for all students regardless of the students' capability. Other products use pre-tests to determine the students' capability levels and then have them follow a single path with an adjusted starting point. Others still use adaptive technologies that regularly alter students' paths based on continuous assessments.

Products that change the learning path based on student capability, and thus deviate from a strictly curriculum-aligned path, may see limited use in classrooms, as teachers face pressure to adhere closely to the curriculum. However, following a single path could limit the benefits of individual-use products which could otherwise tailor content to individual student capability levels. Understanding what amount of matching instruction to students' learning levels is most effective in classrooms given these competing pressures is an important question for governments implementing EdTech.

Is use of only instructional videos enough to improve learning outcomes? What is the marginal value of more advanced features? To what extent can teachers be expected to integrate advanced

[29] See Pritchett's arguments about the importance of coherence in Education systems (Pritchett 2015).

[30] See high-level estimations in landscape section.

features with their pedagogy? The Rapid Evaluations showed that teachers mostly used instructional aid products to show videos. Product companies often envisioned their products to be used in more advanced ways. More evidence is needed on the value of instructional videos alone, the additional value of using more advanced features, and on how well teachers can integrate these advanced features into their classroom practices. This will lead to more realistic expectations and more pragmatic product selection.

STRATEGIES FOR EVALUATING PRODUCTS: ADVICE FOR IMPLEMENTERS

This section gives recommendations on what evaluation strategies to use when implementing an EdTech product. These recommendations combine insights from running the Rapid Evaluations, insights from working with implementers currently using EdTech, and lessons from running other evaluations of education interventions. These recommendations are meant for implementers.

WHY USE FOCUSSED EVALUATION STRATEGIES?

First, impact on learning, and not merely the scale of the technology which has been adopted, should be at the forefront of any conversation on EdTech. Focussed evaluation strategies are a way to gather information on how likely it is that the products are leading to increased learning.

Second, focussed evaluation strategies are needed because product quality is not easily discernible. The Rapid Evaluations exercise showed that the quality of EdTech products varies greatly and basic product information was not a strong signal of quality. Features which appeared impressive to experts sometimes went unused by teachers. Slick production quality that looked attractive at times had limited pedagogic value. Ease of use in a classroom was hard to predict based on a product demo. Even regular users of the product found it was difficult to understand if the product was helping students learn.

Implementers should thus regularly evaluate products and use evaluation results for product selection and on-going refinement. Most implementers conduct at least one round of product evaluations when they select which product to use. In addition, implementers should conduct a rapid process evaluation of the product shortly after initial roll-out. This evaluation will allow them to gather quick feedback to let them know what aspects of implementation should change. While scaling up the product, implementers should conduct a rigorous impact evaluation to ensure that the product is increasing learning outcomes.

The following are stage-wise recommendations.

EVALUATION FOR PRODUCT SELECTION

Ideally, implementers should look for products that have shown positive effects on student learning in similar contexts. To date, few products in India have been rigorously evaluated. The insights from the section *Recommendations based on Rapid Evaluation Findings* may be used to guide product selection though they are not comprehensive of all product types and features. A comprehensive rubric may aid initial product assessment as well. The rubric used by product reviewers for the Rapid Evaluations is attached as Appendix 4.

INITIAL EVALUATION AFTER IMPLEMENTATION

Implementers should conduct a rapid, low-cost process evaluation shortly after initial implementation to assess how implementation is going and to identify potential course corrections. This initial evaluation should use rapid qualitative data collection and seek to identify gaps in the implementation rather than the impact of the product on learning outcomes.

The evaluator should gather data from multiple sources and triangulate information for this evaluation. To conduct the Rapid Evaluations, backend MIS data, interviews of school staff and students, and expert reviews were combined to develop an overall picture of product use. In most cases, data from these different sources pointed in the same direction. In some cases, the data disagreed. Interpreting this agreement or disagreement helped describe a nuanced picture of product use.

The evaluator should also seek to use backend data for this evaluation. In the Rapid Evaluations, backend product data provided numerous valuable insights into the products, particularly on how frequently and for how long products were being used. Backend data has the advantage of providing information about all users instead of a sample. This data may be taken from an existing product dashboard or taken from product companies' central systems. Ideally this data should be analysed independently. Choices about what data to present, such as whether to drop or retain students with low use, could dramatically alter the interpretation of the information. As a downside, obtaining, cleaning, and analysing data often took a large amount of work and could be infeasible in some contexts.

As an example of the usefulness of backend data, Figure 23 shows how interview responses differed from MIS data on weekly product use for EdTech Lab products. Without the MIS data, estimations of use levels would have been inaccurate.

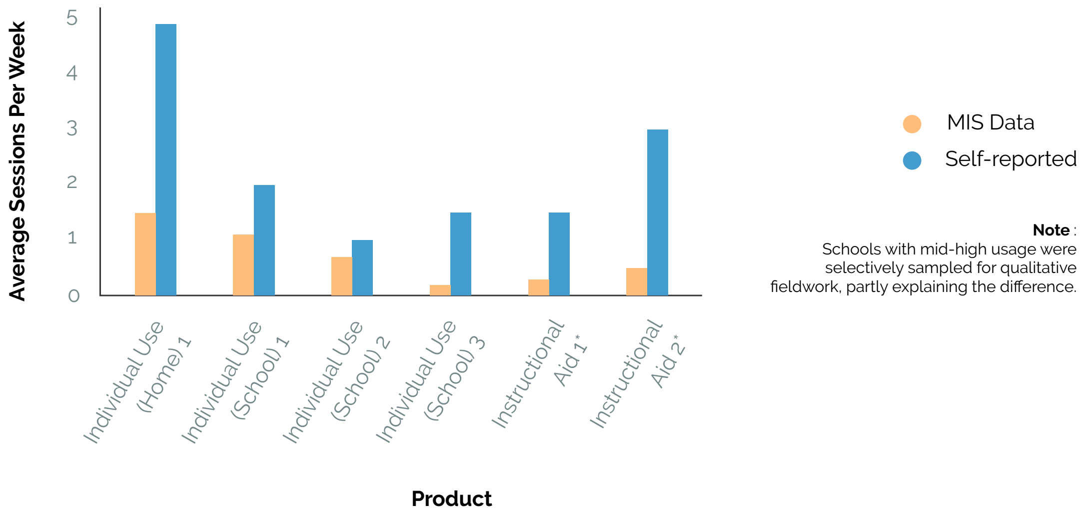


FIGURE 23: MISMATCH BETWEEN MIS DATA AND SCHOOL STAFF REPORTED USE

When observing product use, the evaluator should check if students understand the material. During classroom observations for the Rapid Evaluations, observers had difficulty determining if students were genuinely engaged with the content or merely excited to use the hardware. When conducting such observations, observers should build-in checks that assess how well students understand the content.

The evaluator should use general student opinions about learning and engagement cautiously. Student interviews should focus on how students interact with the product's features. Student perceptions about overall quality may not be a reliable indicator. For all products, at least half of the students said they liked the product and thought it helped them learn. This is despite the fact that some products were reviewed highly negatively by experts. To illustrate this misalignment, Figure 24 shows the relationship between student and expert opinions. Points away from the line of equality represent disagreement between students and experts. For example, products above the line of equality were rated more favourably by students. The product rated the least helpful by students was rated the fourth highest by experts.

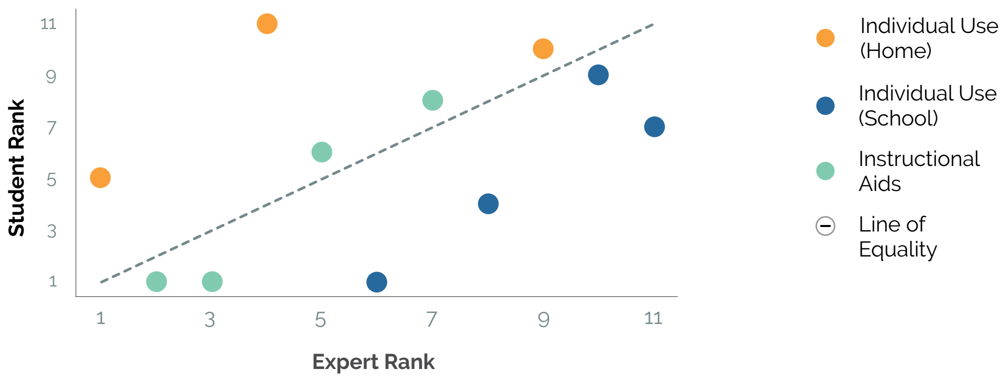


FIGURE 24: STUDENT PERCEPTIONS OF LEARNING VS EXPERT ASSESSMENTS OF PRODUCT QUALITY[31]

IMPACT EVALUATION DURING SCALE-UP

Once the EdTech implementation has stabilised and is being scaled up, the implementer should conduct a rigorous impact evaluation to assess the impact of using the product on student learning outcomes.

The implementer should seek out an external evaluator to conduct the impact evaluation. Impact evaluations require precise measurement and careful application of statistical methods. Thus, in most cases, implementers will not have the capacity to conduct a rigorous impact evaluation on their own.

The impact evaluation should, if possible, employ a randomised design. Randomised evaluations are generally more rigorous than "quasi-experimental" designs. Further, a rigorous randomised evaluation will typically require a smaller sample size than a similarly designed quasi-experimental evaluation.

The evaluator should ensure that student learning assessment data are accurate and unbiased. For most impact evaluations of EdTech products, the most important outcome will be student learning

[31] Three products tied for rank 1 based on student opinion. All three received 100% favorable reviews. Student reviews were not collected for one product. Thus only 11 products are presented.

gains. Thus, careful and precise measurement of learning levels are key to ensuring accurate results. After a recent change to the Right to Education Act, more and more states are administering "summative assessments" to students to track learning outcomes on a regular basis. These data, if high quality, could greatly reduce the time and effort required to conduct an impact evaluation. However, before relying on summative assessment data, evaluators should perform internal consistency checks (e.g. inspect the data for suspicious "jumps" in the distribution) and, ideally, random in-person follow-up checks to verify the accuracy of the data.

REFERENCES

Babu, Nikhil M. 2016. "Not web, but cobweb: With no teachers, computers gather dust in MCD schools." The Indian Express, 02 April. Accessed May 06, 2019. https://indianexpress.com/article/cities/delhi/not-web-but-cobweb-with-no-teachers-computers-gather-dust-in-mcd-schools/.

Banerjee, Abhijit V., Shawn Cole, Esther Duflo, and Leigh Linden. 2007. "Remedying education: Evidence from two randomised experiments in India." The Quarterly Journal of Economics 122 (3): 1235-1264. Accessed May 07, 2019. https://doi.org/10.1162/qjec.122.3.1235.

Banerjee, Abhijit, Rukmini Banerji, James Berry, Esther Duflo, Harini Kannan, Shobhini Mukherji, Marc Shotland, and Michael Walton. 2016. "Mainstreaming an Effective Intervention: Evidence from Randomised Evaluations of 'Teaching at the Right Level' in India." NBER Working Papers No. 22746. Accessed May 07, 2019. http://www.nber.org/papers/w22746.

Barrera-Osorio, Felipe, and Leigh L. Linden. 2009. "The use and misuse of computers in education: Evidence from a randomised experiment in Colombia." Policy Research Working Paper 4386 (World Bank). Accessed May 07, 2019. http://documents.worldbank.org/curated/en/346301468022433230/pdf/WPS4836.pdf.

Beg, Sabrin A., Adrienne M. Lucas, Halim Waqas, and Umar Saif. 2019. "Beyond the Basics: Improving post-primary content delivery through classroom technology." Cambridge: NBER Working Paper 25704. Accessed May 07, 2019. http://www.nber.org/papers/w25704.

Bursztyn, Leonardo, and Robert Jensen. 2015. "How Does Peer Pressure Affect Educational Investments?" The Quarterly Journal of Economics 130 (3): 1329–1367. Accessed May 06, 2019. https://academic.oup.com/qje/article/130/3/1329/1935006.

Business Line Bureau. 2019. "HRD Ministry launches Operation Digital Board." The Hindu Business Line, 20 February. Accessed May 06, 2019. https://www.thehindubusinessline.com/news/education/hrd-ministry-launches-operation-digital-board/article26319604.ece.

Campbell, Kim, Hila Mehr, and Ben Mayer. n.d. "Education Technology in india: Designing Edtech for Affordable Private Schools." Accessed May 07, 2019. https://edtechindia.files.wordpress.com/2013/01/education-technology-in-india-designing-ed-tech-for-affordable-private-schools.pdf.

Carrilo, Paul, Mercedes Onofa, and Juan Ponce. 2011. "Information Technology and Student Achievement:Evidence from a Randomised Experiment in Ecuador." IDB Working Paper Series, No. IDB-WP-223, (Inter-American Development Bank (IDB)). Accessed May 07, 2019. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1818756.

Clark, Donald. 2019. "What is 'adaptive' learning?" Donald Clark Plan B, 12 February. Accessed May 06, 2019. https://donaldclarkplanb.blogspot.com/2019/02/what-is-adaptive-learning.html?m=1.

Cristia, Julian, Pablo Ibarraran, Santiago Cueto, Ana Santiago, and Eugenio Severin. 2012. "Technology and Child Development: Evidence from the One Laptop Per Child Program." IDB Working Paper No. IDB-WP-304. Accessed May 07, 2019. https://publications.iadb.org/en/publication/16431/technology-and-child-development-evidence-one-laptop-child-program.

Das, Ankan. 2019. "Dear Indian Edtech Startups, Taking The Traditional Education System Online Is Not Disruption." Inc42, 06 February. Accessed May 06, 2019. https://inc42.com/features/dear-indian-edtech-startups-taking-the-traditional-education-system-online-is-not-disruption/.

Dwary, Anurag. 2017. "Reality Check Of Madhya Pradesh Schools, At Top Of National Shame List." NDTV, 23 July. Accessed May 06, 2019. https://everylifecounts.ndtv.com/no-electricity-teachers-madhya-pradesh-schools-get-f-15554.

Fergusson, Gibson. 2013. "The language of instruction issue: Reality, aspiration and the wider context." In Multilingual Education in Africa: Lessons from the Juba Language-in Education Conference, by Hamish McIlwraith (ed.), 17-22. London: British Council. Accessed May 07, 2019. https://www.teachingenglish.org.uk/sites/teacheng/files/C413%20Juba%20Publication_FINAL_WEB%20ONLY%20v3.pdf.

GoI. 2012. Household Consumption of Various Goods and Services in India 2011-2012. "National Sample Survey 68th Round, Ministry of Statistics and Programme Implementation." Accessed May 07, 2019. http://mospi.nic.in/sites/default/files/publication_reports/Report_no558_rou68_30june14.pdf.

He, Fang, and Leigh L. Linde. 2008. "How to Teach English in India: Testing the Relative Productivity of Instruction Methods within the Pratham English Language Education Program." Working Paper 1-71. Accessed May 07, 2019. http://www.leighlinden.com/PicTalk%20Working%20Paper%202008-07-02.pdf.

Khaitan, Ankur, Anmol Shankhwar, Nishant Jeyanth, Mankaran Kharbanda, Nikhil Dulipala, and Shivani Jhunjhunwala. 2017. "Online Education in India: 2021." KPMG in India and Google. Accessed May 07, 2019. https://assets.kpmg/content/dam/kpmg/in/pdf/2017/05/Online-Education-in-India-2021.pdf.

Lai, Fang, Linxiu Zhang, Qinghe Qu, Xiao Hu, Yaojiang Shi, Matthew Boswell, and Scott Rozelle. 2012. "Does Computer-Assisted Learning Improve Learning Outcomes? Evidence from a Randomised Experiment in Public Schools in Rural Minority Areas in Qinghai, China." Working Paper 1-29. Accessed May 07, 2019. https://pdfs.semanticscholar.org/cb64/8a5c4d122f4283fe02dc9d79bd9a0ebe32ec.pdf.

Lai, Fang, Linxiu Zhang, Xiao Hu, Qinghe Qu, Yaojiang Shi, Yajie Qiao, Matthew Boswell, and Scott Rozelle. 2013. "Computer assisted learning as extracurricular tutor? Evidence from a randomised experiment in rural boarding schools in Shaanxi." Journal of Development Effectiveness 5 (2): 208-231. Accessed May 07, 2019. https://doi.org/10.1080/19439342.2013.780089.

Linden, Leigh. 2008. "Complement or Substitute? The Effect of Technology on Student Achievement in India." Working Paper No. 17 (infoDev). Accessed May 07, 2019. http://documents.worldbank.org/curated/en/804371468034237060/pdf/448630NWP0Box31er17010Gyan0Shala111.pdf.

Maharana, Sudarsan. 2018. "Computer Aided Learning labs fail to promote computer education in Odisha." Indian Express, 08 October. Accessed May 06, 2019. http://www.newindianexpress.com/states/odisha/2018/oct/08/computer-aided-learning-labs-fail-to-promote-computer-education-in-odisha-1882586.html.

Manzar, Osmana. 2015. "ICT in schools still a distant dream." Live Mint, 12 February. Accessed May 06, 2019. https://www.livemint.com/Opinion/x7oL14yFezaUuhE7wT3ZlI/ICT-in-schools-still-a-distant-dream.html.

MHRiD. 2018. "Implementing Personalised Adaptive Learning at Schools." New Delhi: Department of School Education & Literacy, Ministry of Human Resource Development, Government of India.

Mo, Di, Johan Swinnen, Linxiu Zhang, Hongmei Yi, Qinghe Qu, Matthew Boswell, and Scott Rozelle. 2013. "Can One-to-One Computing Narrow the Digital Divide and the Educational Gap in China? The Case of Beijing Migrant Schools." World Development 46: 14-29. Accessed May 07, 2019. http://dx.doi.org/10.1016/j.worlddev.2012.12.019.

Mo, Di, L. Zhang, j. Wang, W. Huang, Y. Shi, Matthew Boswell, and Scott Rozelle. 2015. "Persistence of Learning Gains from Computer Assisted Learning: Experimental Evidence from China." Journal of Computer Assisted Learning 31 (6): 562-581. Accessed May 07, 2019. https://doi.org/10.1111/jcal.12106.

Mo, Di, Linxiu Zhang, Renfu Luo, Qinghe Qu, Weiming Hunag, Jiafu Wang, Yajie Qiao, Matthew Boswell, and Scott Rozelle. 2014. "Integrating computer-assisted learning into a regular curriculum: evidence from a randomised experiment in rural schools in Shaanxi." Journal of Development Effectiveness 6 (3): 1-24. Accessed May 07, 2019. https://doi.org/10.1080/19439342.2014.911770.

Mo, Di, Yu Bai, Matthew Boswell, and Scott Rozelle. 2016. "Evaluating the Effectiveness of Computers as Tutors in China." 3ie Impact Evaluation Report 41 (International Initiative for Impact Evaluation (3ie)) i - 45. Accessed May 09, 2019. http://www.3ieimpact.org/evidence-hub/publications/impact-evaluations/evaluating-effectiveness-computers-tutors-china.

Muralidharan, Karthik, Abhijeet Singh, and Alejandro J. Ganimian. 2019. "Disrupting Education? Experimental Evidence on Technology-Aided Instruction in India." American Economic Review 109 (4): 1426-60. Accessed May 07, 2019. https://www.aeaweb.org/articles?id=10.1257/aer.20171112

Penuel, William R., Lauren Bates, Lawrence P. Gallagher, Shelley Pasnik, Carlin Llorente, Eve Townsend, Naomi Hupert, Ximena Domínguez, and Mieke VanderBorght. 2012. "Supplementing literacy instruction with a media-rich intervention: Results of a randomised controlled trial." Early Childhood Research Quarterly 27: 115-127. Accessed May 07, 2019. https://doi.org/10.1016/j.ecresq.2011.07.002.

Piper, Benjamin, Yasmin Sitabkhan, Jessica Mejía, and Kellie Betts. 2018. "Effectiveness of Teachers' Guides in the Global South: Scripting, Learning Outcomes, and Classroom Utilisation." RTI Press Publication No. OP-0053-1805 (RTI Press). Accessed May 07, 2019. https://doi.org/10.3768/rtipress.2018.op.0053.1805.

Popova, Anna, David K. Evans, and Violeta Arancibia. 2016. "Training teachers on the job: What works and how to measure it. The World Bank, 2016." Policy Research Working Paper 7834 (Africa Region, Office of the Chief Economist, World Bank Group). Accessed May 06, 2019. https://openknowledge.worldbank.org/bitstream/handle/10986/25150/Training0teach0nd0how0to0measure0it.pdf?sequence=1&isAllowed=y.

Pritchett, Lant. 2015. "Creating Education Systems Coherent for Learning Outcomes: Making the Transition from Schooling to Learning." Working Paper, Research on Improving Systems of Education (RISE). https://www.riseprogramme.org/sites/www.riseprogramme.org/files/inline-files/RISE_WP-005_Pritchett_1.pdf

Pritchett, Lant. 2018. "The Politics of Learning: Directions for Future Research." Working Paper, RISE. https://www.riseprogramme.org/sites/www.riseprogramme.org/files/publications/RISE_WP-020_Pritchett.pdf

PTI. 2018. "Hi-tech! Over 40,000 Kerala government school classrooms become digital." Financial Express, 15 July. Accessed May 06, 2019. https://www.financialexpress.com/education-2/hi-tech-over-40000-kerala-government-school-classrooms-become-digital/1245456/.

Singh, Abhijeet. 2015. "How standard is a standard deviation? A cautionary note on using SDs to compare across impact evaluations in education." Guest Post, The World Bank. https://blogs.worldbank.org/impactevaluations/how-standard-standard-deviation-cautionary-note-using-sds-compare-across-impact-evaluations

The Economist. 2019. "The perils of learning in English." The Economist, 23 February. Accessed May 06, 2019. https://www.economist.com/leaders/2019/02/23/the-perils-of-learning-in-english.

Vesselinov, Roumen, and John Grego. 2017. "Hello English Efficacy Study." Central Square Foundation. Accessed May 07, 2019. http://comparelanguageapps.com/documentation/HelloEnglish_2017Study.pdf.

Wang, Haiwen, and Katrina Woodworth. 2011. "Evaluation of Rocketship Education's Use of DreamBox Learning's Online Mathematics Program." California: Center for Education Policy SRI International. Accessed May 07, 2019. https://www.dreambox.com/wpcontent/uploads/downloads/pdf/DreamBox_Results_from_SRI_Rocketship_Evaluation.pdf.

Wennerstenl, Matt, Zubeeda Banu Quraishy, and Malathi R. Velamuri. 2015. "Improving student learning via mobile phone video content: Evidence from the BridgeIT India project." International Review of Education 61 (4): 503–528. Accessed May 07, 2019. https://doi.org/10.1007/s11159-015-9504-y.

World Bank. 2018. "World Development Report 2018: Learning to Realize Education's Promise." Washington, DC: World Bank. https://www.worldbank.org/en/publication/wdr2018

Appendix 1:

INFRASTRUCTURE LANDSCAPE

SCHOOLS-BASED PRODUCTS

EdTech products require hardware (computers, tablets, or a digital screen), reliable electricity, and in some cases access to the internet. Access to this infrastructure varies across schools. About 60% of students go to a school with electricity, 10% go to a school with internet connectivity, and 16% go to a school with the basic infrastructure to use an instructional aid-style product.[32 33] Figure 25 shows the distribution of schools by availability of infrastructure.

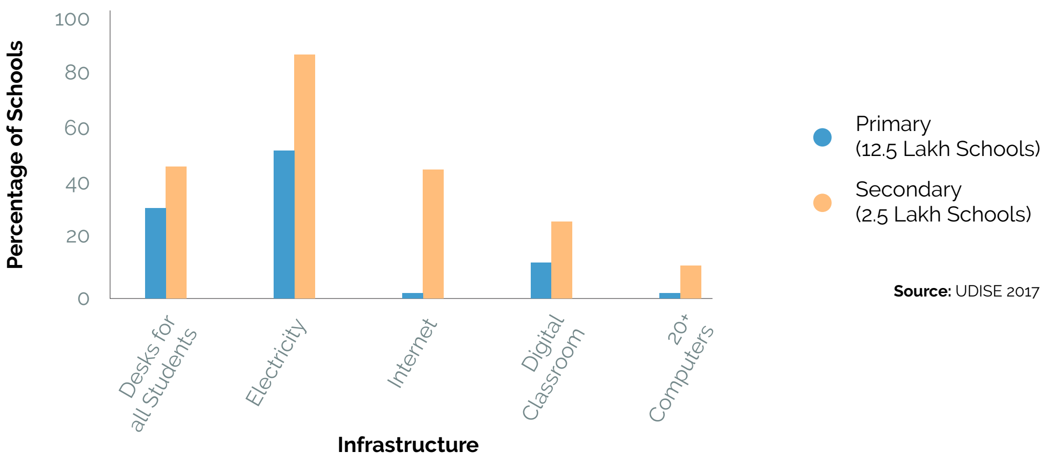


FIGURE 25: INFRASTRUCTURE AVAILABILITY IN SCHOOLS

HOME-BASED INDIVIDUAL-USE PRODUCTS

Infrastructure is also a hurdle for home-use products, though rapidly rising rates of smartphone ownership and access to internet are quickly bridging the gap (Figure 26). Roughly 30% (40 crore) of Indians have internet access, over 20% (29 crore) own a smartphone, more than 10% (1.5 crore) own a computer, and 2-3% (2.5 crore) own a tablet. These numbers are projected to grow. By 2021, 74 crore are projected to have internet access with another 47 crore projected to have smartphones (Khaitan, et al. 2017). Adoption of home-use products has mostly been limited to high-income populations in tier one cities, but this will likely change as these major access constraints change.

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[32] All school hardware data is from Unified District Information on School Education (UDISE) for the year 2017. These numbers could be marginal underestimates of the actual number of students that have access to this infrastructure. Larger schools that have more students have better infrastructure on average.

[33] The number of Digital Classrooms may be misleading. Anecdotes suggest that many computer labs go unused. For Rajasthan, see Manzar (2015); for Delhi, see Babu (2016); ; for Madhya Pradesh, see Dwary (2017); for Odisha, see Maharana (2018).

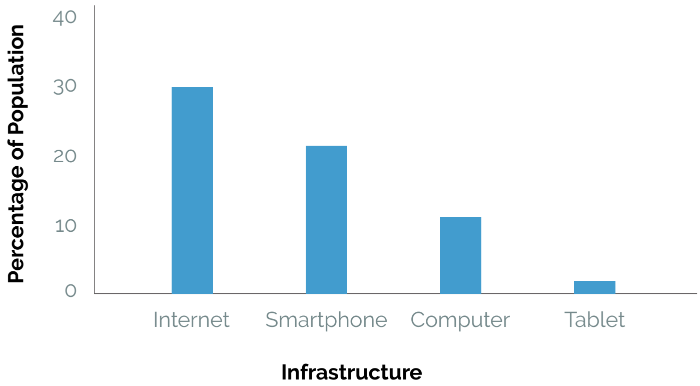

FIGURE 26: INFRASTRUCTURE AVAILABILITY IN HOMES

Source: www.statistica.com (2018)

Appendix 2:
COST AND FEATURES TRADE-OFF FOR HARDWARE AND SOFTWARE

EdTech instructional aids are typically implemented using either smart boards or a combination of a desktop computer and a projector/television. Individual-use products are typically used on a tablet or desktop computer. Salient features and approximate costs of each hardware option in the Indian context are provided in Table3 below.

	Individual-use		Instructional aid	
	Tablet	**Desktop**	**Smartboard**	**Basic ICT**
Longevity (years)	3	5	5-8	5
Touchscreen (Enhanced Interactivity)	Yes	No	Yes	No
Screen size (inches)	7-10	15.6-28	65-82	32-40
Space requirements*	Lockable charging closet	Computer lab	Blank wall, control over lighting	Blank wall, control over lighting
Electricity requirements	Intermittent	Consistent	Consistent	Consistent
Electricity use per device (Watts)	12-15	200-300	350-750	250-380
Internet requirements	Software dependent	Software dependent	Software dependent	Software dependent
Components	Tablet, charger, headphones	Monitor, CPU,[34] headphones	Smartboard, CPU projector, monitor, speakers,UPS[35]	Television, Monitor, CPU, speakers, UPS
Price per hardware unit (₹)	5,000 - 8,000	21,000 - 55,000	1,25,000 - 1,50,000	35,000 - 74,000
Software cost per year (₹)	0 - 41,250	0 - 41,250	8,000 - 18,000	8,000 - 18,000
Minimum estimated cost per student per year (₹)	2,900	5,500	1,300	400

Note: Prices based on retail price of a single unit of the product without any scale discounts. Software costs for individual-use products start at 0, as some home-based products use the freemium model. However, school-based individual-use products would likely start around ₹800/year/student. Assumes 3-year lifespan on tablets and 5-year lifespan on hardware. Assumes 30 students per class. Instructional aid-style product prices include support. Price data on product software, hardware and support sourced from 12 product companies and publicly available information on other products. Price data on headphones, laptops and tablets sourced from online wholesale website (India Mart).

TABLE 3: COST AND FEATURE TRADEOFFS

[34] Central Processing Unit
[35] Uninterruptable Power Supply

Appendix 3:
MIS DATA

Of the seven individual-use products, six provided student-level data. They key components of such were:

- **Session data** – Student activity mapped to each unique use-session to understand use at the most granular-level.

- **Time used** – Every session mapped to a corresponding login and logout time. Only three products could provide this, while the other three only provided unique login dates.

- **Question Attempts** – Data for each individual question attempted with date-time stamp and whether correctly answered.
  - Further, four products provided data to map each question to a granular topic-/sub-topic master list. This was especially useful to assess 'adaptivity'.

- **Use of different features** – Data on the use of different features of a product such as explanatory videos, problem solutions, practice questions, etc.

- **Learning assessments** - Standardised and regular assessments of student progress. Only one product was conducting these.

Of the five instructional aid products, three provided data, two at the teacher-level and one at the school-level (since multiple teachers used common logins). They key components of such data were:

- **Session data** – Teacher activity mapped to each unique use-session.

- **Time used** – Every session mapped to a corresponding login and logout time.

- **Use of subjects** – Data on subject each resource/module accessed.

- **Use of different features** – Data on the use of different features of a product such as explanatory videos, problem solutions, practice questions, etc.

Table 4 below shows what data was available for the 12 products.

MIS Data	Individual Use Products						
	School-based				Home-based		
	P1	P2	P3	P4	P1	P2	P3
	Y	Y	Y	N	Y	Y	Y
Student-level	Y	Y	Y	N	Y	Y	Y
Session Data	Y	Y	N	N	N	Y	N
Time Used	Y	Y	N	N	Y	N	N
Question Attempts	Y	Y	Y	N	Y	Y	NA
Topic/Sub-topic Mapping	N	Y	N	N	N	N	N
Use of Different Features	Y	NA	N	NA	Y	N	NA
Learning Assessments	Y	N	N	Y	N	N	NA

MIS Data	Instructional Aid Products				
	P1	P2	P3	P4	P5
	Y	Y	Y	N	N
Teacher-level	N	Y	Y	N	N
School-level	Y	Y	Y	N	N
Session-level	N	Y	Y	N	N
Time Used (Teacher-level)	N	Y	Y	N	N
Time Used (School-level)	Y	Y	Y	N	N
Usage of Subjects	Y	Y	Y	N	N
Usage of Features	Y	Y	Y	N	N

TABLE 4: MIS DATA AVAILABLE BY PRODUCT TYPE

Appendix 4:
EXPERT RUBRIC USED IN RAPID EVALUATIONS

Item	Category
PEDAGOGY/CONTENT	
Content and interface suitability	**Content coverage:** Number and range of topics gives good coverage for target subjects. Item bank large enough to support variety of learners and progression pace. High range of difficulties covered.
	Content navigability: Content easy to navigate, many paths to learning. Content highlights easy to apply action points.
Pedagogy	**Pedagogy:** Modern and holistic pedagogy. Based on an updated language teaching/learning philosophy. Holistic approach to learning the subject (math/Hind).
	Progression and organisation: Progression with presentation and/or practice promotes learning. Content is organised.
	Assessment: Product has a method of ongoing assessment. High quality formative and summative assessments.
	Engagement: Material is engaging. Material builds user confidence. Cultural sensitivities have been considered.
Future contextualisability	**Understandable:** Content and examples easy for rural user to understand
	Interface: Easy for users with low digital literacy
	Teacher burden: Product easy for government school teachers to use
SUBJECTS	
Math	**Accuracy:** Language is accurate for concepts
	Conceptual development: The digital content promotes and supports conceptual understanding.
	Multiple representation of mathematical concepts: Use of multiple representations (such as graphs and diagrams) and or simulations; wherever applicable.
Language	**Listening:** Listening tasks are appropriate with well-defined goals. Tasks are authentic and close to real world situations. They are efficiently graded according to complexity.
	Reading: Reading texts are interesting to learnings and adequately graded.

Language	**Speaking:** Speaking activities initiate meaningful conversations. Tasks allow sufficient opportunities for individual response, or pair and group work where appropriate.
	Writing: Tasks lead to achievable goals and are well-targeted to learning levels.
	Vocabulary: The load (number of new words in each lesson) is appropriate to the level of learners. Distribution is well done. Words are efficiently repeated and recycled across chapters.
	Grammar: Examples interesting and well-contextualised.
	Language and pronunciation: Dialogues sound natural and real. Language is easy to understand. Instructor's Speech has appropriate voice modulation with correct pronunciation.
INSTRUCTIONAL DESIGN	
Scaffolding	**Appropriate:** Scaffolding (recall, reiterate, help tools etc.) should have accurate content which maps to the concept being taught.
	Well-placed: Scaffolding should be well-placed.
General instructional design	**Learning objectives:** Learner is able to meet the learning objectives (as measured through assessment)
	Language: Language used is as per level of understanding of the intended audience.
	Visuals: The module is visually appealing, and visuals support the concept audio
	Support text: On screen text is relevant, contains key words/formula and is not too long (is crisp).
	Interactivities: Interactivities are mapped to content, relevant, challenging but not difficult (No giveaways), and include a variety.
Content delivery	**Content delivery:** Audio is spoken clearly, is not accentuated, is crisp and maps to on-screen text.
Objective mapping	**Objective mapping:** Learning objectives are measurable and map to the curriculum or learning framework
Lesson plan	**Lesson plan:** The flow of the content/topics is logical and maps to the lesson plan as per the curriculum (With respect to enabling and terminal objectives).
Assessments	**Placement:** Assessments are placed appropriately to test learning of each learning objective
	Distractors: Distractors promote learning and are not giveaways.
	Questions: Questions are clear to understand and map to the objective and content covered for that objective.
	Feedback: Feedback, if any, guides the learner to right answer without giving away the answer (In practice questions).

USER EXPERIENCE	
Design and flow	**Efficiency:** Navigation is intuitive. All functions, assistance and feedback must be intuitive and logical, especially for users who are not tech/internet savvy. Users can solve tasks without unnecessary effort. Product reacts quickly.
	Accessibility: Product enables access to its content and learning for people with disabilities, or special needs, or enables access through the use of assistive technology.
	Information architecture: Information architecture focuses on organising, structuring, and labeling content in an effective and sustainable way. The goal is to help users find information and complete tasks as per the pedagogical approach.
	Perspicuity: Product is easy to learn how to use and get familiar with. Product enables user to navigate through the product; and its topics, learning modules and exercises.
	Error prevention & support: Support is readily accessible and useful. Help users recognise, diagnose, and recover from errors. Includes onboarding, assistance & feedback experience.
Attractive	**Attractiveness:** Product solution design is consistent and well-balanced. Pleasing and innovative aesthetics of media elements. UX design must be consistent and convincing. Form, function and materials must be in an appropriate balance with one another.
	Stimulation: Product is exiting and motivating to use. Solution addresses emotional and cognitive needs. The sum of expectations, behaviors and reactions before, during and after use must be predominantly positive and preferably delightful. Desirable for repeat use.
	Novelty: User feels the overall product experience is novel and innovative. The product strategy, concept and implementation help user achieve their learning needs more innovatively
TECHNOLOGY	
Technology	**Proven:** Solution is built using scalable technology components. Solution does not require re-architecture to support operations at high scale.
	User-centered: The product development is based on a user-centered process; the quality of the research methods and their subsequent integration are indicative of the user-centeredness of the design process.
	Clear and usable: The solution provides interfaces to enable integrations to other infrastructure modules such as user registries, content repositories, data repositories, etc.
	Self-improving: Solution gets better with increasing use. The solution has a sound strategy for automated or semi-automated improvements in productivity and usefulness with increasing use.

Technology	**Adaptive:** Product adapts to different expectations and user requirements.
	Navigation through levels: Navigation is easy through learning levels.
Scalable, contextualisable	**Contextualisable:** Solution is contextualisable through configuration and/or extensibility hooks which do not break the solution's upgradeability or stability.
	Modular: Solution is designed in a modular way. The solution should be deconstructable so that it can operate as independent modules. It should plug and play with other infrastructure modules (users, content, data, recommendations, etc.).
	Scalable: Solution scales easily with increasing use. Solution is built using scalable technology components. Solution does not require re-architecture to support operations at high scale.
Data	**Well-instrumented:** Product is well-instrumented to generate usae and interaction telemetry
	Debugging: Product generates detailed error logs for debugging errors and issues.
	Manageable: Solution provides clear and configurable data visibility and management policies and does not put user and organisztion privacy requirements at risk.
Implementation support	**Dashboards:** Dashboards are simple and easy for the teachers and admin to understand the dashboards. Dashboards are built (in terms of reporting formats) keeping in mind teacher capacity in government schools. Dashboards/product provide prescriptive guidelines to teachers/students to use the product effectively.
	Famaliarisation time: Product provides initial time for teachers/ students to get comfortable with using the technology.

Appendix 5:
TABLE OF REVIEWED STUDIES

Study	Product Type(s) Evaluated	Grade, Sample, & Geography	Product/Program Name
Beg et al. (2019)	Instructional aid	Grades: 8 T: 30 schools; C: 29 schools Punjab, Pakistan	eLearn
Muralidharan et al. (2019)	Individual-use (Adaptive)	Grades: 4-9 T: 310 students; C: 309 students Delhi, India	Mindspark
Mo et al. (2016)	Individual-use (Research group vs. Government)	Grades: 4 & 5; T1: 22; T2: 22 schools C: 80 schools Shaanxi, China	Not specified
	Individual-use Instructional aid	Grades: 4 & 5 T1: 40 schools; T2: 40 schools C: 40 schools; Shaanxi, China	Not specified
Mo et al. (2015)	Individual-use	Grades: 3 & 5 T: 36 schools; C: 36 schools Shaanxi, China	Not specified
Mo et al. (2014)	Individual-use	Grades: 3 & 5 T: 36 schools; C: 36 schools Shaanxi, China	Not specified
Lai et al. (2013)	Individual-use	Grades: 3 & 5 T: 36 schools; C: 36 schools Shaanxi, China	Not specified
Mo et al. (2013)	Individual-use	Grades: 3 T: 150 students; C: 150 students Beijing, China	One Laptop Per Child
Cristia et al. (2012)	Individual-use	Grades: 1-5 T: 209 schools; C: 110 schools Rural Peru	One Laptop Per Child
Lai et al. (2012)	Individual-use	Grade: 3 T: 26 schools; C: 31 schools Qinghai, China	Not specified

[36] The following was accounted for while reporting effect sizes: (a) In all cases (except 1), they are defined in terms of standard deviations of normalised test scores; (b) For interventions spanning more than one academic year/study period, the combined effect size over the entire period is reported; (c) The reported effect size is picked from the specification with the most expansive set of controls, especially baseline scores of the target subject (wherever reported); (d) Effect sizes for only the target subjects of the intervention are reported.
Significance of effects reflected by *** p<0.01, ** p<0.05, * p<0.1

[37] Based on a conversion rate of 1 USD = 69.99 INR (as on 10 May 2019).

[38] The authors reported disaggregated effects for grades 3 and 5: 0.25 & 0.26 respectively with a standard deviation of 0.08. We report 0.26 as a combined effect for both grades.

Target Subject(s)	Dosage, Intensity, and Duration of Intervention	Effect Sizes in Standard Deviations[36]	Cost-per student
Math Science	Total Dosage: 32 hours Intensity: 120 mins/week Duration: 16 weeks	Math: 0.12 *** Science: 0.089 **	Intervention: ₹ 1,050/year At scale: ₹ 630/year
Math Hindi	Total Dosage: 27 hours Intensity: 90 mins/week Duration: 18 weeks	Math: 0.37 *** Hindi: 0.23 ***	Intervention: ₹ 1,050/year At scale: ₹ 140/month
English	Total Dosage: 48 hours Intensity: 80 mins/week Duration: 36 weeks	Research group: 0.18 *** Government: 0.00	Intervention: ₹ 734/student (Researcher-implemented)
English	Total Dosage: 48 hours Intensity: 80 mins/week Duration: 36 weeks	Instructional aid: 0.08 ** Individual-use: 0.03	Not specified
Math	Total Dosage: 80 hours Intensity: 80 mins/week Duration: 60 weeks	0.26 ***[38]	Not specified
Math	Total Dosage: 53 hours Intensity: 80 mins/week Duration: 40 weeks	0.16 ***	Not specified
Math	Total Dosage: 32 hours Intensity: 80 mins/week Duration: 24 weeks	0.12 **	Not specified
Math Mandarin	Total Dosage: N/A Intensity: N/A Duration: 40 weeks	Math: 0.17 * Mandarin: 0.01	₹ 14,000 per laptop
Math Language (not specified)	Total Dosage: N/A Intensity: N/A Duration: 52 weeks	Math: 0.062 Language: - 0.030	₹ 14,000 per laptop
Mandarin	Total Dosage: 32 hours Intensity: 80 mins/week Duration: 24 weeks	0.20 ***	Not specified

Study	Product Type(s) Evaluated	Grade, Sample, & Geography	Product/Program Name
Carrilo et al. (2011)	Individual-use (Adaptive)	Grades: 3,4, & 5 T: 8, C: 8 (schools) Guayaquil, Ecuador	Más Tecnología
Barrera-Osoria & Linden (2009)	Instructional aid	Grades: 9 & 10 T: 48 schools; C: 49 schools Rural Colombia	Computers for Education
Linden (2008)	Individual-use (Rural schools; substitute to existing teaching)	Grades: 1-3 T: 12 schools; C: 11 schools Ahmedabad, India	Gyan Shala Computer Assisted Learning Program
	Individual-use (Urban schools; complement to existing teaching)	Grades: 1-3 T: 19 schools; C: 18 schools Ahmedabad, India	Gyan Shala Computer Assisted Learning Program
He et al. (2008)	Individual-use	Grades: 1-5 T: 48 schools; C: 49 schools Thane, India	The PicTalk program developed by Pratham
	Individual-use Instructional aid	Grades: 1-5 T1: 61 schools; T2: 61 schools T3: 60 schools; C:60 schools Mangaon, India	The PicTalk program developed by Pratham
Banerjee et al. (2007)	Individual-use (Adaptive)	Grade: 4 T: 55 schools; C: 56 schools Vadodara, India	Software developed internally by Pratham

Target Subject(s)	Dosage, Intensity, and Duration of Intervention	Effect Sizes in Standard Deviations	Cost-per student
Math Spanish	Total Dosage: 267 hours Intensity: 180 mins/week Duration: 80 weeks	Math: 0.37 * Spanish: 0.16	Not specified
Math Spanish	Total Dosage: Not specified Intensity: Not specified Duration: 80 weeks	Math: 0.088 Spanish: 0.077	Not specified
Math	Total Dosage: 200 hours Intensity: 300 mins/week Duration: 40 weeks	- 0.57 **	₹ 2,800/year
Math	Total Dosage: 200 hours Intensity: 300 mins/week Duration: 40 weeks	0.28	₹ 2,800/year
English	Total Dosage: N/A Intensity: N/A Duration: 40 weeks	0.278 ***	~ ₹ 1,050/year
English	Total Dosage: N/A Intensity: N/A Duration: 40 weeks	Individual-use: 0.345 ** Instructional aid: 0.320 ** Combined: 0.328 **	~ ₹ 1,050/year
Math	Total Dosage: 160 hours Intensity: 120 mins/week Duration: 80 weeks	0.394 ***	₹ 1,050/year

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