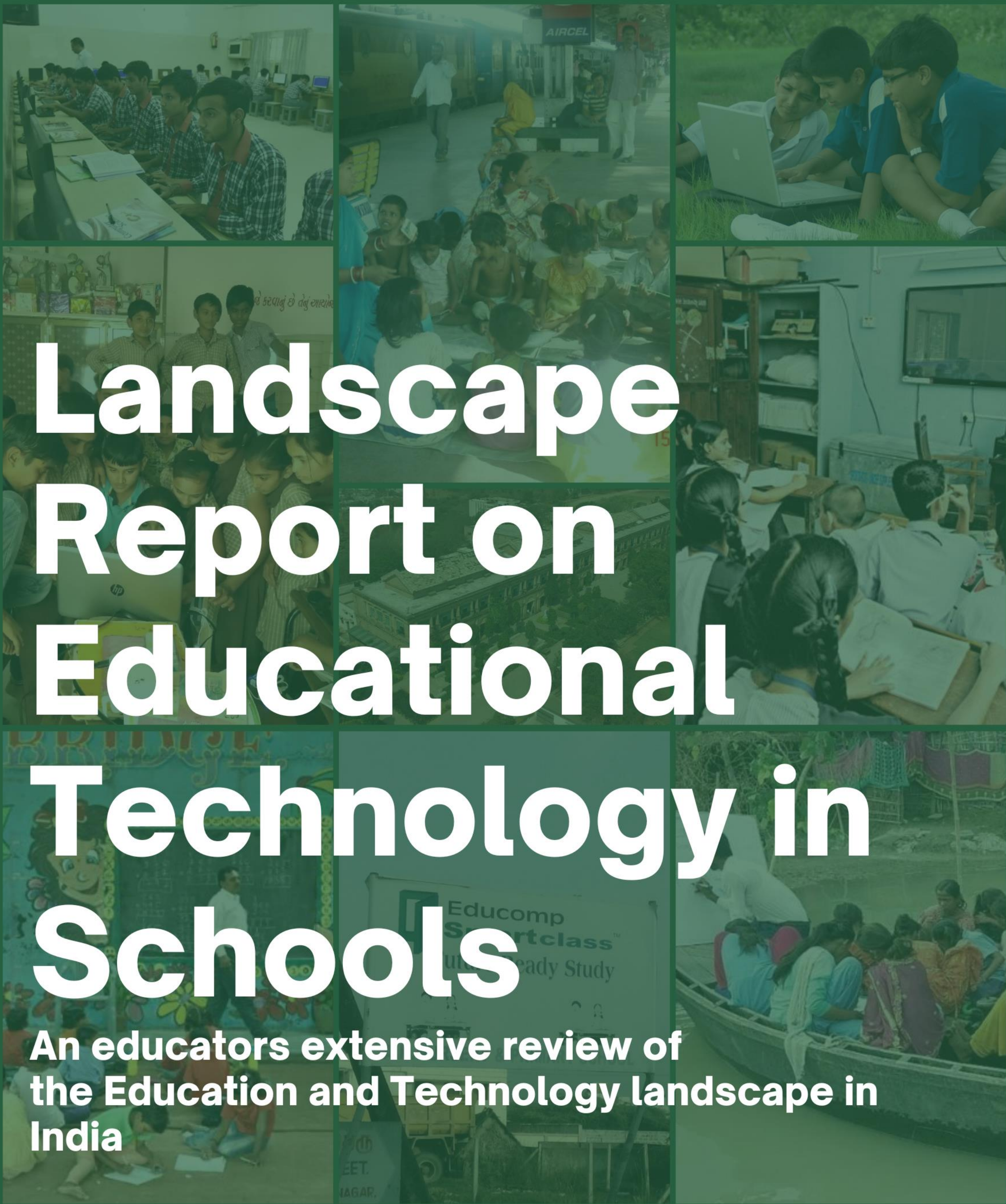

Landscape Report on Educational Technology in Schools

An educators extensive review of the Education and Technology landscape in India

November 2022

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> ***"The schooling process itself is a technological device to embellish, enhance, facilitate, and evaluate human attempts to foster learning in other humans."***

Introduction

1. Educational Technology was not regarded as a significant input into the schooling process till the advent of explicit technological devices in the classroom. The term gained currency with the use of audio-visual media, when technologies of the times— film strips, projectors, radio and video cassette players, etc. became readily available as consumer devices. However, production of software for these devices remained beyond the reach of the teachers and the schooling system. It truly caught the attention of the schooling system with the modern-day information communication technologies (ICT), which include computers, internet, and a host of allied accessories and applications. Modern ICT is essential '**digital technologies**', in which information is processed in a binary digit format. We will hence use the term 'digital technologies' in this report.
2. Researchers have attempted to ground it in schooling theory; and in the process stumbled upon the idea that Educational Technology has always been an integral part of the classroom, if not the entire schooling process. Digital technology is merely a newer version. This may appear to be *post-facto* seeking of legitimacy for the older attempts to support teaching-learning processes. But argued from first principles, there appears to be support to the view that the schooling process itself is a technological device to embellish, enhance, facilitate, and evaluate human attempts to foster learning in other humans.
3. The evolution of mass education has resulted in a school model which involves structuring and age-wise stratification, organization of curricula, training of teachers in the techniques of instruction, classroom processes, enablers such as timetables or lesson plans, and the assessment system for learning. And one can readily find analogous processes in other large-scale technology-mediated efforts. This report invokes this model as a convenient device through which the schooling process and the use of technology enablers can be understood. The model enables the situating of technologies of every vintage along a continuum; analyze and compare them; and trace the evolution of educational technology as a whole in enhancing the development of children—their learning as well as their ability to learn.
4. In the search for justifications for the introduction of ICT, a pertinent question to ask would be: ***What do newer iterations of technology have to offer to the learner, the teacher, and indeed the schooling process as a whole, which justify investments for replacing existing technologies with digital technologies and with newer digital technologies becoming available by the day, their renewal or upgradation?***

5. Despite the attraction that modern day digital technologies hold for many, and the innumerable demonstrations of the potential of digital technologies to address a variety of schooling processes, particularly transformation of teaching-learning, a strong empirical case is yet to be made, for suggesting digital technologies as an essential component of the school infrastructure. What constitutes relevant or appropriate digital technologies is also still to be clinched. At least public schooling across the country have not shown a marked leaning towards such investments. Perhaps, affordability—digital technologies infrastructure may well be the most significant capital as well as operating expense in schools—may have played a very big role in dissuading them. In the absence of unambiguous research pointing to definitive ways in which digital technologies can bring about transformations in education, policy makers tasked with apportioning their budgets will continue to be faced with the dilemma of choosing to invest on ICT. The diversity of choices, particularly of digital technologies enabled content support[1], tends to further complicate the choices.
6. In the Indian context, the absence of data—what is indeed available, however large, is neither independent nor representative of the size. Almost every conceivable version of infrastructure—hardware and software, every generation of software applications, and every way of packaging and delivering content will find proponents; every developer and vendor[2] claims success. For the academic researcher, these constitute at best anecdotal, and less charitably self-serving proofs of concepts. There may not exist any reliable techniques by which these reports can be read together. To add to the complexity is the fact that the structure and curriculum is predominantly defined centrally (a common core curriculum prescribes what students are tested for in their school leaving examinations), the justification being to provide a level playing field for all. At the same time, on the ground there is a mind-boggling diversity in terms of infrastructure, facilities, and support to education.
7. In recent times, the Unified District technologies Information System for Education (UDISE)[3], is emerging as a reasonably reliable information source for school data[4] As per the UDISE+ 2020-21 report, the country reports a total of 1,509,136 schools, with 622,575 (41.25%, ranging from 14.49 to 100% across states) reporting the existence of computers, of which 601,857 (39.88%, ranging from 13.73 to 100 across states) are claimed to be functional. Only 369,909 (24.51%, ranging from 0 to 100% across states) schools report having internet access[5].
8. There can be gross variability amongst the schools in terms of number of units of computers or quality

[1]Most times it is the same content, packaged using different media techniques, but rarely differing pedagogically.
[2]Throughout this report, reference to developers and vendors includes not only commercial players, but also individuals, groups or organizations involved in supporting the infusion of digital technologies by providing know how, training, creating, and sharing free and open-source software (FOSS) applications, digital resources, etc.
[3]UDISE data can be accessed at https://udiseplus.gov.in/#/home and can be mined down to individual school data through the school's geo portal at https://schoolgis.nic.in/
[4]This database is essentially a compilation of data submitted by schools through a self-reporting format each year. There is no mechanism built in to the process to validate the data. Nevertheless, this remains the only source for a pan India snap shot of the school system.
[5]Internet connections can come in many forms (broadband to fiber, to mobile hotspots) with widely varying bandwidths and speeds.

of internet. This is particularly critical as schools deploy shared computing facilities. The compiled UDISE+ data does not reveal the student to computer ratio. To provide a sense of the variability a data set[6] from a school group (managed by a state government agency) was analyzed. This revealed the following:

> Of the total 826 schools, with a typical strength of 250 (classes 6 – 10; 50 students per class), only 39 schools were equipped with 10 or more computers (range 10 – 26) and internet; of the remaining, 379 schools had at least one computer with a projection system; and 277 schools had no computers. If these 39 schools were to aspire to provide each student a computer session (independent access to the computer over a 45-minute class), the student would likely get 30–40 such sessions every year, less than once a week (a typical school operates about 200-240 days a year).

9. While this data may not be representative of the population, it is safe to conclude that no meaningful generalization of access to digital technologies is possible from available data sources. Adding further variables like the vintage of the computers, availability of specific accessories, range of software or even their present working condition[7], is bound to further reduce the potential access. Suffice it to conclude that even in schools equipped with an adequate number of computers, students are not assured of adequate computer time.
10. While viewed from a pan-India perspective, the landscape appears rather bleak, what must be recognized is the population size. The same 2020-21 report of UDISE+ reports 26.44 crore (264 million) children and 96.96 lakh (9.6 million) teachers across the 1.50 million schools. One can readily infer the existence of a very large number of extremely small schools, typical of the remote rural habitations. These schools can be run with much smaller infrastructure. Some of the larger schools both private and public have managed to establish larger infrastructure. This is particularly true at the plus two level, where computer related subjects are offered as optional courses[8].
11. Despite the challenges of penetrating such a distributed schooling system, developers and vendors have found niche applications and identified sufficiently large spaces[9] for their services. From the perspective of reaching out to larger and larger numbers of children and provide them a chance too, a more informed analysis and appreciation of the potential would be necessary.
12. It is in this context that this landscape[10] report has attempted to map the situation and assess the possibilities of using digital technologies for education. Though it is common to refer to the teaching-

[6]This is an unpublished data of a school group organizing about 800 schools. To avoid revealing identities, further details are not reported here.
[7]In fact, assured electricity is a far more critical factor, in many places.
[8]The focus on infrastructure is because it is the single most significant variable in the digital technologies debate. This issue has been discussed elaborately in the report.
[9]The report will use the term 'education spaces' to include both the commercial ('market') as well as the community (not for profit) based approaches to providing digital technologies for use in Education. Private / Commercial providers produce and supply hardware and also provide proprietary software and content that runs on the hardware. Not for profit entities (and commercial entities that promote FOSS and OER) also produce and supply software and content.
[10]The choice and appropriateness of using a Landscape model to map and analyze digital technologies in education is explained in Appendix 1.

learning process as the central idea of any school, applications of digital technologies can span a much larger canvas. School automation, teacher professional development, online platforms and services, large scale networking and information systems can together serve to relieve the teacher from administrative tasks, enable and equip her to plan and enhance instruction. digital technologies thus should not be viewed from the rather narrow canvas of classroom learning, but should span a wider range of applications.

13. The analysis and conclusions of this report is expected to help a wide range of individuals and organizations. The State-run system ranging from the Central Government to the local bodies will be able to identify possible interventions that can benefit from these technologies, assess their preparedness, and prioritize their investments. Individual private schools will be able to assess their present interventions and redesign it to optimize benefits. The developer and vendor will be able to appreciate the complexity and the challenges posed by the diverse educational system and reorient their initiatives[11]. There are sufficient areas of *green field* development waiting to be explored and reached out to. Also, despite the diversity, each of the segments of the school system are large enough to support the initiatives of entrepreneurs. Guidance for possible directions such initiatives ought to take can be gleaned. Most significantly, the sparse and scattered presence of a wide range of digital technologies provides a good opportunity for the education researcher to study the scenario and its effects, the constraints and opportunities in order to recommend not only appropriate directions for digital technologies use, but also meaningful educational applications.
14. The aspiration for such a report should stem from a desire to look beyond the clutter and ask: ***What can digital technologies do for education? Could these benefits have been derived without ICT? Can it help us define who a digital technologies-enabled student or teacher is? And therefore, how shall we prepare them to benefit from ICT?***

[11]The term developer used includes not-for-profit work, including those by NGOs, academic institutions, FOSS communities etc.

Part I The Educational Landscape

1.0 The Indian School Setting

1. The school education landscape consists of individual schools, larger groups of schools, administrative and management structures, and organizations.
2. These organizations at the National, State and local levels perform multiple roles. They are a part of the larger teacher preparation system— they organize pre-service teacher training; they support the drawing up of the curricular canvas of schools— participate in the development of curriculum, syllabi, curricular resources (textbooks, for instance); they also provide academic support to the public schools (managed by the government and local bodies) by organizing professional development activities. These organizations include institutions like the councils for educational research and training (NCERT at the national level and SCERT / SIE at the state level), District technologies Institutes of Education and Training, Block and Cluster resource centers. They are also called upon to support the managerial effort— undertake surveys and collect data for instance.
3. What distinguishes the Indian school system is its humongous size, geographical spread and its extreme diversity, finding parallels to which, anywhere else in the world, almost impossible. At one extreme we have makeshift classrooms functioning from railway platforms, the shade under a large tree, and even a boat. Some of these, organized through voluntary effort, are perhaps the best chance of retrieving children from penury and provide them a possible chance to join the mainstream. At the other extreme are schools with the best of infrastructure and resources and even academic programs that can compete with the best in the world. Between these two extremes lie thousands of schools with a wide variety of clientele, spanning the entire socio-economic spectrum; of a variety of management types, both public and private; and a variety of emphases on activities and resources.
4. What again distinguishes the Indian school system is its desire for common standards, which has translated to the implementation of a common curricula across all stages of school education. Children across these schools study the same subjects and syllabi, through similar textbooks and school routines. This flows out of a National Curriculum Framework, with minor adaptations at the State level and a common examination system (organized separately by different Boards, but following a common core). The similarities end here.
5. The common educational program prescription gives, to an undiscerning outsider to the system, an impression of a monolithic structure and kindles an image of an equitable access to education.
6. Of the over 1.5 million schools in India, a little over 1 million of them are set up and managed by the State and less than 0.5 million are categorized as private. About 29 per cent of India's 179 million school children attend private schools. State-run schools include large systems of schools run by the Central Government (for example, Kendriya Vidyalayas (1248 schools) and Navodaya Vidyalayas (661

schools)), those run by the Ministry of Education or Social Welfare of the State Governments, Municipal Councils of larger cities or other local bodies, etc.

7. Schools come in all sizes, offer all stages of schooling or only some of the stages. In the case of rural schools, some isolated habitations are likely to have fewer children of the school-going age, and some others requiring multiple schools. As a part of Government policy, schools have been set up in every habitation. These schools tend to subsist with the bare minimum physical structures, personnel, and support infrastructure. Urban schools on the other hand tend to serve a larger population and have more classrooms, more teachers, and are more likely to have a broader infrastructure.
8. Placed on a continuum, habitations range from very large metropolis to micro-habitations dispersed in challenging geographies— in forests, on islands, in deserts or on mountains. Support infrastructure, in particular transport, internet or mobile connectivity and electricity are non-uniformly distributed across these habitations. Even within large habitations, socio-economic diversity imposes differing levels of access to the support infrastructure. Schools in these habitations, both public and private, tend to inherit many of these constraints.
9. The privately managed schools can range from individual schools to large groups of schools under a common management; varying in size from an overall school strength of less than a hundred students across multiple grades to very large schools with strengths of many thousand students; managed by individual owners, trusts and societies, religious and social organizations, or large corporates; affiliated to and deriving their core practice from the prescriptions of state boards of education, or national boards— Central Board of Secondary Education (CBSE - 24,000 schools), the Council for the Indian School Certificate Examinations (ICSE - 2400 schools), the International General Certificate of Secondary Education (IGCSE - 500 schools), schools offering the International Baccalaureate program (IB - 200 schools), and the National Institute of Open Schooling (NIOS), and depending on the fee structure they are able to demand and sustain, varying facilities and educational exposure.
10. Parents and the community are rarely equipped to make demands on the type and range of facilities and resources available for their children in schools. The emergence of local pressure groups and activism of local leaders has resulted in an enhanced attention towards school improvement in many places; but this is yet to become a wide spread and critical catalyst of the process. Community participation in schools (school development and management committees) and parent associations are examples of local pressure groups and have successfully demonstrated their potential in many, but isolated cases.

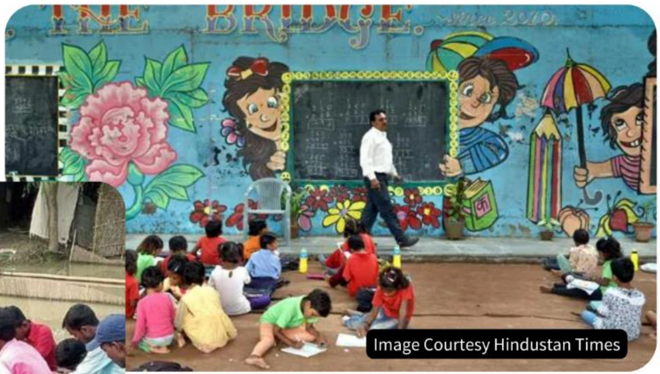


Image Courtesy Hindustan Times

A Boat School

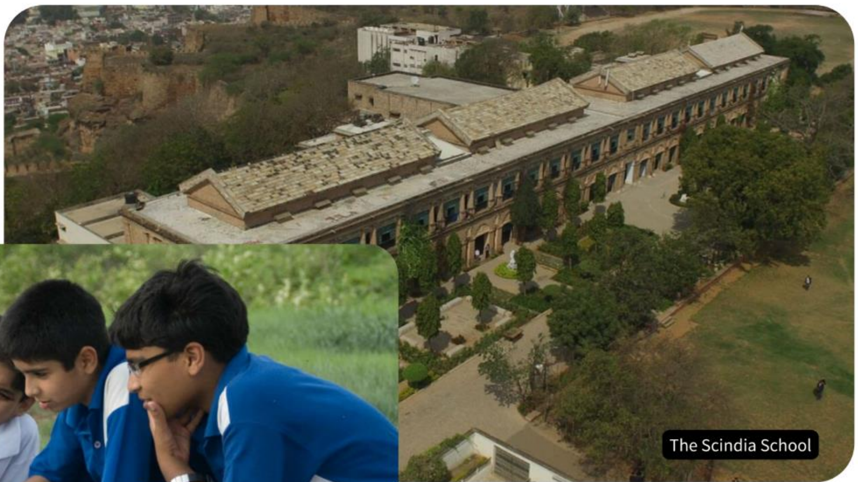

Image Courtesy The Telegraph

A Roadside School

A platform School


Ruchika Social Service Organization

As good as an ivy league school


The Scindia School


The Scindia School

Where affordance is not an issue.

Schools across the spectrum

Image Courtesy: Youth Ki Awaaz

Image Courtesy: MInt

Image Courtesy: Hindustan Times

India began the setting up of its educational system, post-independence, under extremely dire circumstances. The absence of adequate numbers of educational opportunities to provide equitable access to the growing numbers of aspirants has continued to constrain the system. Consequently, admissions to higher education are restrictive, controlled through a very narrow filter of entrance examinations. *This in turn has converted school leaving certificate examinations and entrance examinations into high stake examinations*. On the one hand, it has skewed the school's attention, particularly in higher grades (9–12) to focus on student preparation for examinations. On the other, a mushrooming of coaching and extra school support has developed into a parallel industry. With the infusion of modern information and communication technologies, some of these services have acquired very high visibility and has begun to attract the attention of parents who perceive the need for additional support for their wards. It must be noted however, that this phenomenon of coaching classes is restricted to a few select options of higher education, like engineering, medicine, business schools, and law schools etc.[12]. The number of opportunities available in this sector and the number of students aspiring for these paths are also limited. But a disproportionate social value attributed to these professions has helped sustain the glamor associated with these high-stake examinations.

2.0 The Educational Context

1 Over time, the aims of education have been settled. With minor variations, universally, there is an agreement that Education should result in developing capabilities of children; developing sensitive, responsible and competent citizens; and inspiring and equipping children with the requisite knowledge and skills to pursue a career of choice. The ease of translocating to larger towns and cities; or even other countries in pursuit of opportunities has also enabled children graduating out of schools and colleges to pursue further education and careers in places far removed from their own. This has not only helped universalize the opportunities available, but also led to the emergence of a universal canvas for education.

2 The formal School system has also emerged as the vehicle of choice for educating children. Newer opportunities for education, particularly at the higher level emerge as informal arrangements, but soon merge into the formal system. A good example is the emergence of a wide variety of courses relating to computer literacy, computer education, computer applications etc.

3 For private/unaided schools to be viable, purely in terms of economic sustenance, they have to acquire adequate scale in terms of numbers of students, because tuition fees as the primary and in most cases, the only source of income for schools hits the limit of affordability. In urban places, where the density of schools is high, raising of fees can only be at the cost of a competitive advantage. The investments made on these schools therefore vary, affecting all inputs ranging from the quality of teaching learning, the quality of infrastructure and the variety of learning experiences afforded to each student. Disparities between schools are common. Apart from physical challenges leading to

[12]The coaching industry is primarily a reaction to the business opportunities that high stake examinations have thrown up. Sectors where large-scale selection procedures are not the norm, this industry is hardly present. While its ability to distract and even disrupt the attention of the schooling system is readily visible, to treat it as a component of the educational process would be a misnomer. In fact, even the seeking of additional support from a neighborhood tutor is symptomatic of the school's failure to take note of the student's needs and provide remedy. Nevertheless, the coaching industry is growing in size and increasingly penetrating lower classes, which can unfortunately result in legitimizing coaching support, further weakening schools.

infrastructural deficits (habitations not adequately served with electricity or connectivity, for instance), access to funds play an important role[13] in whether a school will accommodate newer infrastructure (technology products and services, for instance).

4 In the Indian context, the state has intervened to establish a reasonably comprehensive set of minimum requirements. Hence one encounters a more or less common structure across all schools -- ten years of common schooling preceded by a pre-schooling stage and followed by a pre-university stage of two years. The national policy and curriculum framework has also established a uniform system in terms of curricula, progression through grades and stages of schooling. Requirements of physical infrastructure, qualifications and numbers of teachers, common minimum academic resources (textbooks at all stages, requirements for labs at higher levels, for instance) are mandated. Traditions of schooling practice has also led to the establishment of a common range of social and cultural activities in the schools.

5 While the intent of these prescriptions is to enable equitable access to educational opportunities despite socio-economic and other constraints, in practice these have pushed the bench marks lower. Schools have compromised on a variety of resources and facilities; and schooling processes tend to merely comply with state requirements (typically, students are provided the bare minimum infrastructure and the focus is on completion of the syllabi and preparation of children for examinations).

6 Completing the syllabus prescribed for the grade in itself is a massive dilution of the curricular goals. It focuses attention on only the information content. This has in turn transformed the prescribed textbook as the sole arbiter of the curriculum. The prescribed textbook acquires a larger-than-life role; teachers lose the freedom to interpret the syllabi in terms of the curricular goals and evolve strategies customized to the particular group of children they are teaching. From a purely administrative perspective, the transaction of chapters of a prescribed textbook in the allotted time is a rather convenient way of measuring schooling efficiency and accounting for teacher effort. It also enables large school systems to manage a level of uniformity in teaching learning across the group of schools.

7 The effect of this administratively controlled strategy is manifold:

7.1 One, individual needs of children (even if some of them require more effort to learn the particular topics), are completely sacrificed; they are forever playing catch-up and accumulate enormous backlog of learning each year; they simply get left behind.

7.2 Two, the authors of the textbooks have to make sweeping assumptions about the availability of resources and opportunities for the teaching-learning of different topics. The immediate implication is that activities that require equipment or access to external resources are rarely

[13] There is a growing perception, fueled by frequent demands for hike in fees in some schools, that the private school system is guided by a motive to profiteer. Available data however indicates that a large number of private schools are low fee charging, function at a subsistence level, with the bare minimum of facilities and infrastructure.

invoked; activities that require higher levels of cognitive engagement is avoided. Of immediate interest to this report: access to computers and the internet cannot be assumed to be available to all students across all schools and therefore no links to resources from the web, no use of software applications however useful and appropriate, is ever suggested.

7.3 Any deviation, including constructive expansion of the topic to inspire children, help them explore the topic, or understand better requires an adventurous teacher willing to go out of the way to accommodate children's needs at the risk of not completing the syllabi on time. There are, fortunately, many teachers who are willing to do this and have successfully demonstrated ways to bridge learning gaps within the constraints of the administratively shackled system. Innovations in teaching learning, particularly the infusion of information and communication technology depends on the creative efforts of such teachers.

8 Schools have evolved into complex structures. The regulatory framework imposed by the state requires compliance to a large number of rules, the immediate fallout of which is the investment of time and effort in collecting and compiling a variety of information, documenting and maintaining these records. Many of these records are regularly submitted to the authorities.

9 The day-to-day administration and management of the school requires attention to a wide variety of processes. Records of attendance of personnel, finances, inventory and housekeeping, transport (where schools organize these services), communication with parents, etc. require, at times, sophisticated handling of information and their own unique sets of data handling tools and reports.

10 The support infrastructure at the school – laboratories and libraries, electrical and other equipment, add to the complexity of the management of the resources. Organization of events, competitions, celebrations, even examination involve complex administrative and managerial support.

11 In the context of administration and management of groups of schools (and in the Indian context, we have many instances of thousands of schools being managed centrally by various authorities); organization of inter school events; organization of large-scale common examinations; recruitment, transfer and deployment of teachers (in the state governed systems) the complexity of the processes involved are very high.

12 Each of the above instances of administration and management of processes, either within a school or across schools can benefit from automation and use of appropriate information and communication technologies.

13 Schools have a number of processes and activities; they include administration and management at the school level as well at the overall system level (large groups of schools administered centrally); demands on professional skill sets and arrangements; academic support to teachers (continuous professional development); data and its utilization in decision making at both the individual school and the system levels; Organization of events and processes at large scale, competitions, celebrations

and examinations; centralized or large scale production and dissemination of resources, text books for example. Each one of these can benefit from productivity and efficiency measures, which in turn can benefit from automation and the creative use of modern information and communication technologies.

3.0 A Case for Educational Technology Support to Education

1 Traditionally educational technology has been perceived mainly as a support for the teaching learning process and in the classroom. While theorists and researchers have attempted to expand the range and scope of educational technology by suggesting automation of various systems and processes, tools of evaluation for instance, the prevalent understanding treats educational technology as synonymous with teaching aids.

2 Teaching aids have ranged from the ubiquitous black board and chalk, a range of equipment used to demonstrate experiments in science, mathematical instruments to construct diagrams on the black board, models of objects to help visualize concepts, a globe or a diorama for instance, or maps and charts. Designed to serve the needs of a teacher facing a large group of students, they typify a use case for educational technology and many modern technology products are modeled around these ideas -- projection systems, 2d and 3d graphic models and drawing applications adapted for classroom use.

3 With the advent of computing devices like calculators and their evolution into computers, the range and scope of their use in classrooms has greatly expanded. Access to a wide variety of software applications, networked computers, the advent of internet and the web, and storage of information and delivery of applications through the cloud has cumulatively contributed to increased convenience, productivity and efficiency. Not only do they now have implications for the classroom and the delivery of teaching learning, but also holds promise of influencing education, educational administration and schooling as a whole.

4 Digital technology applications are widely being used in variety of business environments for information processing and communication requirements. A wide range of activities are performed by and as a consequence of the use of computers and the internet. This has also created a wide spread space(s) for technologies, devices, software applications, and connectivity. The large and varied canvas of applications also holds promise for the use of digital technologies in schools and school systems, much beyond their use as teaching aids in classrooms.

5 Automation of administrative processes, communication, collection and compilation of data to facilitate decision making constitute a range of applications schools can readily benefit from. Apart from obvious benefits of productivity and efficiency, they can play a big role in relieving the teacher from chores extraneous to her primary role, increasing the time she can devote to enabling students. A comprehensive exposure to possibilities of digital technologies inspires and equips students and

teachers alike to a wider variety of options in higher learning as well as careers. Use of digital technologies by teachers and students also hold the potential of transforming teaching learning practices, affording and enabling greater participation of students in the process and allowing teachers to raise the challenge levels. Access to the web and the larger variety of resources can help expand curricula and equip students to benefit from the wider opportunities available to them in adult life.

6 At a larger system level, digital technologies can result in improved print production, digital repositories of educational resources, web driven services, online course platforms, and data repositories. The communication and networking possibilities of the web and mobile interfaces can also enable communities of practice, teacher networks for instance. This has also opened out the possibilities for the larger community's participation in the schooling process. Lay professionals from outside the school system have responded to the infrastructural or content gaps. Media reports have begun to highlight a variety of issues, resulting in a wider awareness of the constraints and challenges. Teachers have expanded their interventions, developing and disseminating content resources on the web, and researchers and academics have catalyzed initiatives for a range of online resources, infrastructure, policy leanings, support to teachers and online services (the UDISE initiative is an excellent example). At the same time, the appreciation of a gap in the school system's digital technologies efforts has prompted a large number of EdTech developers and vendors who have set up small and large businesses, claiming to provide technology fixes. Many of these have emerged as good proofs of concepts. Very few of them, however, have stood the test of time and change of technology, superseded by similar products based on more recent technologies.

7 Each of these possibilities of digital technologies have been tried out. Some of them have been mainstreamed. It can safely be stated that a strong proof of concept exists for the infusion of digital technologies across the school system. The actual needs of individual schools and the scale at which they can operate will vary. But, a universal acceptance of the possibilities has however eluded the school system. An analysis of the impediments is presented later in the report.

4.0 The Geography of the School System

1 Irrespective of socio-cultural demands, economic constraints, etc., schools have acquired a common structure; classrooms, timetables, academic calendars, subject teachers, curricular and co-curricular activities, examinations and progression of children through the grades are common features of all schools.

2 Socio-economic constraints (or their absence) have resulted in wide deviations, particularly in terms of extraneous infrastructure, but conformity in terms of curriculum and its transaction is the norm.

3 Enormous diversity can be found in terms of size of school, both in terms of what grades are offered;

number of students enrolled; academic and other resources; professional resources, particularly teacher qualifications and quality.

4 The co-existence of private and public schools has also resulted in accentuating the diversity; large, economically prosperous private schools, not so well to do private schools; deprived public schools; and relatively better funded public schools. Common minimum expectations from all schools have not aided a demand for better facilities and quality from better endowed schools. Areas with extreme geographies and communities with extreme resource constraints suffer from grossly ill-equipped schools.

5 Functional autonomy at the administrative level in the case of private schools and affordability or other constraints in the case of public schools has restricted the system from prescribing continuous upgradation of teacher quality. Inadequate access to opportunities for such in service teacher upgradation and support affects teacher quality.

Part II The Educational Technology Landscape

5.0 Evolution of Educational Technology and its adaptations in Schooling

1. Ever since the advent of the desktop computer, a half century ago, the expectations from this technology have been on a rise. The growth of the technology itself has seen an exponential rise. Today, digital technologies can best be described as the backbone of a connected world, fueling a communication and information interchange revolution which has brought under its fold, almost every aspect of human endeavor.
2. While individual schools, particularly economically-sound private schools took the initiative of establishing digital technologies infrastructure, the first Government initiative of introducing school students to computers was in the form of the Computer Literacy and Studies in Schools (CLASS) project, begun in 1984, which was followed by a policy directive in the National Policy of Education, 1986. Apart from aiming at a general computer literacy, development of software applications, particularly in Science and Mathematics was also encouraged. The project amply demonstrated the potential of computers in supporting teaching learning. Based on BBC microcomputers and BASIC programming, they were soon superseded by the early versions of a desktop computer (PC with a disk operating system functioning out of floppy disks). The sheer scale at which they became available and the apparent versatility in addressing common office applications drew the attention of businesses. Schools began to invest on establishing computer laboratories (typically a set of desktop computers, equipped with the then available software). The initial attempts at computer education were restricted by what the systems could then do— an introduction to operating a computer along with common office applications like word processing and database applications.
3. Computer literacy has remained a significant objective of computer education in schools ever since, upgrading itself to encompass later developments in technology. With hardware devices and software applications becoming relatively more complex, the learning curve has only become steeper and a neo-initiate to computers has to invest a large proportion of time and effort to reach a point of operational efficiency. Unfortunately, ease of operating a variety of digital technologies is a prerequisite for the use of digital technologies in education; and a less familiar user is more likely to be dissuaded from trying.
4. With the general failure of the school system to ensure universal access to computers, and teacher training programs failing to integrate digital technologies into educational practice, the need to initiate students (even at secondary and senior secondary levels) and teachers to computer operations continues to hold back meaningful digital technologies infusion into schooling.
5. Digital technologies have evolved over time, adding a mouse and a graphical user interface, which in turn expanded the scope of computers beyond office applications. The advent of hard disks with

larger capacities, processors with greater speeds and multimedia capabilities, a computer could serve many more applications and a variety of software followed.

6. The introduction of multimedia projectors heralded the entry of computers into a classroom. The possibility of projecting the screen added color and versatility to the blackboard, catching the attention of teachers.
7. Beginning in 2004, two IT majors, Intel, and Microsoft played a significant role in popularizing digital technologies in schools. The Intel Teach Program, a worldwide initiative which aimed to help teachers become more effective educators by training them on how to promote problem-solving, critical thinking, and collaboration skills among their students, as well as on effectively integrating technology into their lessons. Through their initiative Project Shiksha, Microsoft sought to deliver affordable software solutions, comprehensive training, and curriculum to teachers and students across schools. Microsoft followed this with the Innovative Teachers Leadership Awards. It must be recognized that the two initiatives by Intel and Microsoft have largely been responsible in catalyzing the establishment of digital technologies infrastructure in schools in India, as well as kindling a growing interest among teachers to explore their use in teaching learning. They were successful in influencing various state governments to invest on digital technologies infrastructure in schools. A large number of teachers and students got their first opportunities at using computers. At the same time, Kerala initiated a similar program for IT literacy using free and open-source software (FOSS) applications and focused on building teacher capacities for both computer literacy and computer-aided learning. If this model had been popularized amongst state governments instead of the 'Wintel' duo, it may have created greater awareness of FOSS[14].
8. In 2004, the Central Government launched the ICT@Schools scheme, a funding vehicle for state governments to establish computer laboratories and associated infrastructure in schools. This expanded on the Educational Technology scheme and the CLASS project.
9. In the absence of widespread internet connectivity and limited resources on the web on the one hand, and the absence of software applications of relevance to schools at the time, the initiative was largely restricted to the Microsoft's software environment (read, Windows and the Office suite). This continued the legacy computer literacy program with an addition — an overriding emphasis on teachers presenting their lessons using Microsoft PowerPoint. In Kerala, the use of FOSS made integrating desktop-based FOSS educational software applications like GeoGebra or Marble easier and provided a richer technology environment
10. These slideshows made through a projection system in the classroom has come to typify classroom

[14]Refer policy brief on 'Outsourced vs integrated models' which compares the Kerala ICT@School model with the BOOT model, this aspect is also covered in para 64

use of ICT; so much so, teachers continue to refer to the slideshows as ppts (a reference to the file extension of these slideshows). Despite the fact, that the presentation software application had nothing to offer most of the time, as a value addition to the teaching of topics, be it in science or mathematics, or languages, or social sciences, thousands of teachers spent enormous time and effort in creating these slideshows and sharing them with fellow teachers. In hindsight, these were indeed a retrograde step for digital technologies in education, as an opportunity to explore meaningful uses of digital technologies to transform teaching learning processes and enabling teachers and children to learn problem solving, critical thinking, and collaboration skills was indeed lost.

11. Largely dependent on financial grants from the Central Government, and the inability of the private school system to garner adequate resources to invest on digital technologies has neither ensured an equitable access to computers and the internet across schools, nor have demands been made on the school system to attempt to utilize the multitude of resources and possibilities of digital technologies to improve productivity, efficiency, and student achievement.
12. The popularity of the classroom equipped with a multimedia projector aided the entry of an interactive whiteboard (commonly referred to as a smartboard). Supported with an internet connection, it claimed the possibility of a much wider fare of educational resources. It did indeed promise a liberation of the teacher from a prescribed resource paradigm, giving her the freedom and involving her in the creation of a learning environment, best suited to the needs of her students. In practice, however, reports of usage of such interactive boards range from the very trivial (displaying downloaded content) to visually-enriched presentations (an A for Apple being supported by the picture of an apple). Rarely do we encounter examples of transformation of teaching-learning, engaging students in seeking, processing, and critically examining multiple resources, formulating their own thoughts and opinions and evaluating the same through peer discussions. Apparently, the issue is not with the possibilities of digital technologies but the brief a teacher approaches her professional practice with — the objectives of her teaching, the understanding she has of the scope of the content and resources, the model of a student and the broader curricular goal of developing autonomous learners.
13. The possibilities of digital technologies transforming teaching learning was further affected by an administratively convenient (in a way lazy) response state education departments made towards establishing digital technologies infrastructure. A favorite model was to outsource the implementation to a private vendor under a build–own–operate–transfer model, the transfer, in practice, happening at a time when the infrastructure had practically outlived its life (mostly due to obsolescence or supersession of technology). Based on a premise of an absence of know -how and capabilities within the school system to operate and manage the digital technologies infrastructure, it resulted in a rather bizarre situation of outsourcing the effort to a digital technologies teacher appointed by the vendor. At

best this person was the caretaker of the infrastructure; rarely was this teacher equipped to handle teaching-learning.

14. A refreshing alternate to this outsourced model was the IT@Schools model of the Kerala State. The departures that this model took included:
    - 14.i participation of the regular teachers in the school in the operation and upkeep of the digital technologies' infrastructure; this was supported by local IT clinics, providing maintenance support;
    - 14.ii Integration of the digital technologies program with the regular curriculum of the school; ensuring the use of the digital technologies' infrastructure in the teaching-learning of different subjects; even the textbooks were redefined and redesigned to fit this transformation;
    - 14.iii Encouraging a community of practice; participation of select teachers in localization and customization of software tools, development of digital technologies-based teaching learning resources, sharing and celebration of these resources;
    - 14.iv The choice of FOSS and Creative Commons licensing for resources generated in the project has led to the use of a wide variety of software applications, particularly those relevant to the various subjects taught and teacher routines (evaluation and learning management for instance); its localization and customization enabling their use in local languages;
    - 14.v The continued participation of the state department[15]; this has resulted in a constant renewal of the project, upgradation and replacement of hardware and software; it has also ensured the maintenance of a bidirectional linkage between the curricular process and the development of digital technologies infrastructure.
15. Apart from addressing the administrative pitfalls of various other implementation strategies, the IT@Schools model holds out the promise of continuous engagement of the school system with developments in digital technologies and consequent upgradation of the teaching learning processes.
16. A major bottleneck to the use of digital technologies is the infrastructure itself:
    - 16.i Technology is constantly evolving and many of the newer possibilities are soon superseded owing to technological limitations, dependence on other technologies which are no more maintained, or a simple absence of support;
    - 16.ii Particular hardware devices are rendered obsolete due to their dependence on specific versions of operating systems (due to driver software for instance); Similarly, software products which are not updated to newer versions of operating systems also have to be given up.
    - 16.iii Many digital technologies products, which have demonstrated their value for transforming education, have failed due to extraneous factors such as those listed above.

[15] Kerala has reduced/ stopped central procurement of hardware for schools. Schools access different sources including panchayats, MLA/MP funds to renew their digital technologies infrastructure, making it more a need-based bottom-up process.

16.iv Among the popular operating environments, except in a few schools, apple computers with the iOS environment are rare; personal computers with Windows operating systems predominate; where projects have made conscious choices to recommend a FOSS environment, Linux operating systems can be found.

16.vWhile many of the software applications (particularly the FOSS variety) are available across platforms (for Linux, windows and iOS), expertise available in schools inhibit a general exploration of a range of educational applications; schools tend to limit themselves to the supplied software applications; computers with the Linux environments are known to have a wider variety of educational software applications.

16.vi Schools which find the resources to establish digital technologies infrastructure at a given point of time, have to maintain the same for a long period of time, due to their inability to financially support renewal and replacement; the consequent creation of electronic junk not only poses an administrative hurdle, but a diminishing number of working units also affects continuation of the digital technologies program. The lack of local support also affects the continued use of the hardware.

16.vii This is particularly the case with Government Schools, where the budgetary provisions are not adequate to cover all the schools and the next turn for a school may not happen soon. The schools attempt to manage with a progressively deteriorating infrastructure, which remains inadequate. Raising of a curricular expectation in such circumstances becomes unreasonable.

17. Many of the digital technologies investments have been for the secondary school system. While this infrastructure becomes available to lower classes in a composite school, the predominant structure in the government school system is that of separate schools for each stage. Hence it is likely that the lower classes do not possess any IT infrastructure.
18. The infusion of multimedia projectors, followed by interactive white boards heralded an attempt to use digital technologies for teaching various subjects; the evolution of graphics and multimedia packages enabling the creation of animations also gave an impetus to the development and infusion of curricular support packages. Various EdTech developers produced multimedia lessons across all grades and subjects, which enabled a teacher access to a ready-made support for her teaching. These were mapped to the existing school curricula.
19. Popularized vigorously, these products caught the imagination of schools and parents alike and a number of schools flaunted their use. The model of support to teaching learning that these packages projected continues to influence the design of EdTech products for curricular support.

A Smart School?

20. The Covid-19 pandemic and the forced shutdown of schools prompted yet another exploration of technology infusion into schooling. Online classrooms emerged as a popular model of reaching out to students in their homes. While online teaching encompasses a variety of teaching-learning practices, from a communication perspective, the model involved the broadcast of a lesson through the internet by a teacher to her students. The students received these lessons at home through a variety of devices— computers, laptops, internet enabled televisions, but mostly mobile phones (smartphones). Many ways of enabling interactions have also been tried out.
21. The feasibility of such communication has also excited the interest of EdTech developers to explore personalized interfaces and mobile applications to reach out directly to students. Inability to afford devices and connections, lack of student access to exclusive devices, not all mobile devices being capable of multimedia communication, and most of all limited penetration of mobile connectivity are some of the limitations identified. Together, they deny meaningful access to a large proportion of students.
22. The mobile platform and the delivery of educational content and resources through mobile apps adds to the complexity. On the one hand it requires the developers to customize their offerings to the needs of various mobile devices (including screen sizes, platforms — android or iOS and versions of these platforms). On the other, it affects a teacher's ability to transact all forms of activities — in a normal classroom, the teacher seamlessly shifted from teacher activity to student activity, from reading to writing to solving problems; all of which require teacher management and oversight. A technology enabled environment seriously hampers this ability, mostly making it unwieldy.
23. Further, localization across the tens of languages used in the school curriculum as the medium of instruction poses a significant barrier. Schools predominantly transact teaching learning in these languages. English as a convenient medium of educational content necessarily limits itself to a small part of the population of school going children across the country.

Part III The present genre of EdTech products and services and their impact on schooling processes

6.0 EdTech Products and Services

1. From the foregoing discussion on the diversity of schooling contexts and the general directions digital technologies infusion into schooling has taken, a broad classification of applications of digital technologies can be gleaned. This in turn points to directions in which digital technologies influences on the educational processes have progressed as well as the gaps they continue to under serve or not serve at all.
2. The diversity of contexts also highlights the enormous segmentation of the EdTech space, with each segment posing unique challenges. However, each of these segments are large enough – contain tens of thousands of schools, teachers and students, making it possible for the developer to invest time and energies.
3. At the same time, the common education system is faced with the challenge of a diverse technology environment, making its use extremely complex, dissipating the limited resources (academic as well as technological) it can garner. In effect, a meaningful direction for the use of technology remains out of reach.
4. At the level of the State, the education system consists of a relatively uniform prescription for educational practice – common curricula, common curricular resources, textbooks for instance, common examinations and evaluation criteria and a common set of languages. This provides an opportunity for defining a common set of educational needs, which technology can support. This in turn can help the diverse set of technology developers to narrow down, align and offer their ware and services to the schools. The absence of such a common understanding of technology needs has, on the one hand contributed to the rather chaotic range of EdTech applications, and on the other discouraged many an EdTech developer from attempting to adapt their products to the requirements. The latter is particularly true in the context of localization and translation into the various languages used in the school system.
5. The ease of developing a product for the English-speaking space is fueled by a variety of reasons:
   - Coding and other software development processes work are largely in English; also, the developer is most comfortable using this language;
   - Indian higher education primarily functions in English;
   - International comparisons and benchmarks can be aimed at; adapting or importing products becomes easy; export is also feasible;
   - Unlike some of the major international languages, say German, Japanese or Russian, a robust infrastructure for translation and native support for operating digital technologies does not exist

in Indian languages;

- Font support for Indian languages have enabled adaptation of the user interface, but expertise in domain specific language use as well as a limited user base inhibit the developer

Across the country, classrooms predominantly use Indian languages for teaching-learning. The potential for the EdTech developer to make products in these languages is large indeed. But for various reasons, both technological, educational, and low demands, the investments of time, effort and money required in maintaining these products across generations of technology is huge. State support, where available, has provided the impetus for localization of products at scale (IT@Schools, Kerala for instance). Assurance of demand brought about by increased digital technologies infusion into schools can also be relevant to the spread of EdTech products into schools functioning in Indian languages. The impetus provided by the National Education Policy (NEP2020) for Technology in Education, holds out a promise.

The discussion of EdTech products and services in the following sections has attempted to categorize them on the basis of use cases. Individual products and services are referred to only as exemplars. This report makes no claim to exhaustively trace all the products and services being used in the system. The categorization, however may help include newer or unlisted products and services into this mapping.

Based on the prevalent use cases of digital technologies in schooling, the following categories of EdTech products and services can be identified:

- For use by students:
    - as tutorial support;
    - as a general-purpose learning support;
    - to acquire computing and other digital technologies related competencies;
- For use by teachers:
    - during teaching;
    - to support teaching / for continuing professional development;
    - for administration of the teaching-learning program;
- For use by a school:
    - for automation of school processes and administration;
    - for outreach and communication;
    - for data applications;
- For use by the larger school system:
    - for academic support to schools and teachers
    - for administration;
    - for outreach and communication;

- through automation of large-scale processes; data applications; provide online services etc.)

A further classification of EdTech Products and Services can be made on the operating environment they function in:

- Custom applications designed for single or a suite of purposes and typically platform dependent;
- Generic applications for general use and typically platform dependent;
- Generic applications for general use with cross platform interoperability;
- Applications designed for particular devices; desktop, mobile, etc.;
- Container applications like multimedia packages for the curriculum;
- Applications with proprietary licenses and requiring upgradations;
- Applications with FOSS licenses and requiring upgradations;
- Digital resources and collections;
- Online applications dependent on internet connectivity;
- Online services supporting access when needed;

A third type of classification is based on the pricing policies the vendor uses:

- Products and services developed or customized for users; funded upfront;
- Products and services sold for a one-time cost;
- Products and services which require upgradations or maintenance at a cost;
- Products and services which are free; including freeware, adware, open source;
- Products and services shared with open licenses;
- Products and services with subscription models; including memberships;
- Products and services with separate costs for container and content resources;

The use of digital technologies in a school setting, and particularly for teaching-learning is majorly influenced by the digital technologies environment — the particular mix of computing devices, enabling infrastructure (networking, internet connectivity, peripheral devices), the context of sharing (the number of terminals rarely reach a 1:1 situation, two or more students at each terminal is the norm), the curricular objectives (digital technologies for digital technologies literacy, for learning computing, for learning other domains, for a wider range of computer applications) and the scheduling (digital technologies usage being restricted to specific time slots) drives the aspirations of how we wish to use ICT, towards what ends and what skills, competencies and appreciation we wish to equip students with.

- The typical digital technologies environment prevailing in schools is that of a digital technologies' laboratory — a room dedicated to the location of computers and peripherals.

- A second common digital technologies environment locates a terminal associated with a projection system in a classroom, designed to support conventional teacher-driven approaches of teaching-learning.
- A third form of digital technologies use driven by a personal device with each individual user had not found favor in the school system, mainly due to the economic constraints, but is being explored with renewed interest after the advent of mobile phones and tablets with a varied range of extended capabilities.
- The socio-economic realities and the absence of an explicit set of educational use cases will continue to define how digital technologies will be used, the first two contexts remaining the most common. At a personal level the third context is likely to gain attention.

11. The different categories of EdTech products and services, operate within the three types of environments described above. The generic desktop or laptop computer still functioning as the gateway, further delimited (or even constrained) by the operating system, the range of software applications (money is rarely available to buy applications, so you make do with freeware or FOSS or bundled products) and the competing demands on shared computing time. Users exposed to FOSS software applications or those equipped with better internet connectivity have a larger range of products and services to choose from.

6.1 EdTech Products and services in the Computer Laboratory:

1. As mentioned earlier, the digital technologies environment most commonly found in schools is a set of computers located in a common space (called a computer laboratory), seating a group of children. This configuration began in the early days of desktop computers and has continued ever since.
2. The primary use of this environment has been to provide hands on experiences (referred to as computer education) to students. Attempts have been made at different times to define a standard content for such courses. But, the changing complexion of technology and the inability of the school system to make digital technologies a universal part of all schools, has hindered such prescriptions. Schools mostly use content developed by a large number of publishers (textbooks for computer education) or invent their own. The focus of the computer education program is to familiarize students to the operation of the hardware devices, typical routines for managing files and folders, operating common software applications, and an introduction to coding.
3. Across the private school system, particularly in the larger (and higher fee-charging) schools, the computer education courses are offered early, even in primary classes. But it is more common to find its roll out in higher classes, typically in secondary schools.
4. At the secondary level, particularly in schools affiliated to Boards at the National level (CBSE, ICSE,

etc.) students are allowed to choose digital technologies-related courses, which tend to have a more structured computer education curriculum. At the senior secondary level, all boards across the country offer computer science and other variants as optional subjects, with a more structured curriculum. The National Skills Framework, providing vocational courses at the secondary and senior secondary stage include many courses leading to careers in Information Technology and allied areas.

5. The most typical range of software applications that find their way into the computer education program are the Operating System itself and applications typically bundled with computers. Typical office applications — word processors and presentation software, drawing and painting applications, media players and browsers (where internet is accessible). Less commonly, spreadsheets and databases, some sophisticated graphics and animation packages and compilers for programming are also included.
6. Microsoft Windows being the most common operating environment, students are more likely to be exposed to applications normally bundled with this system and aided by an attractive pricing policy, may include the Microsoft Office suite. The range therefore includes Paint, Word, Excel, PowerPoint and a few other freeware. Among the more sophisticated software applications, Adobe Photoshop, Google Workspace (Chrome browser, mail and virtual storage) and Autodesk 3D Studio are frequently mentioned.
7. Individual users, schools, and projects which are more aware of the social, legal, and ethical aspects of software licenses show a distinct preference for FOSS Software applications. But even here, except where projects have deliberately attempted to widen the fare, the range of applications hover around the FOSS equivalents like the Linux operating system, Libre Office suite, Mozilla Firefox and a few typical media applications. Among the more informed user community, the range is much larger, spanning not only computer education but also applications used to extend domain learning.
8. The National Digital Technologies Curriculum 2013 provided curricula for students and teachers which focused entirely on educational processes that digital technologies could support. Interestingly, the curricula are generic, and does not mention any hardware or software brands, instead focusing on what can be learnt from the use of ICT. Such curricula remain relevant for a longer period of time.

6.2 EdTech Products and services for Curricular Support:

1. With the advent of graphics and multimedia capabilities of desktop computers, the computer laboratory also emerged as a host to a variety of curricular resources. Attempts to support the teaching-learning of various subjects with media resources were demonstrated and many EdTech developers across the country developed and succeeded in attracting the interests of schools.
2. The computer laboratory as a host of such curricular support failed to attract the attention of subject teachers, who had to circumvent various constraints in their routines in order to incorporate the

laboratory in their teaching-learning program. Elaborate lesson planning (taking children to the lab, after a few regular classes, for instance) were demonstrated. The advent of a projector and an interactive board in the classroom shifted the action into the regular classroom and has continued ever since.

3. Popularly referred to as multimedia support to education, they typically consist of media packages—text, audio-visuals, animations, and interactive sections; are linked to a common interface and aimed at teaching-learning; and are aligned to the curriculum, in particular the chapter flow of the prescribed textbooks.
4. The technologies used in these packages have developed over time, incorporating newer ways of packaging and delivering the content—a richer audio-visual fare, a larger range of interactivity, more sophisticated tracking and control of navigation and diagnostics which compile and report student progress, etc. Market factors have also encouraged developers to offer these as technologically locked collections.
5. On the other hand, these offerings have mostly remained stagnant pedagogically. They continue to be modeled for a classroom where the prescribed textbook is transacted. For the EdTech developer, it is indeed a tight rope walk. Schools, for various reasons exhibit great inertia in transforming classrooms. Curricula have remained agnostic to technological possibilities and the EdTech developer is left supporting the status quo.
6. Developers indeed claim improvements to their products. But, beyond the compulsions of adapting to changes in technology (flash animations being no more supported, for instance), upgradation of each of the media resources do not find justification, in the absence of a corresponding curricular demand, which invariably is non-existent.
7. A typical example of such a curricular support package is Tata Class Edge (see box below). As mentioned at the beginning of this part of the document, any reference to particular products or services is only to use it as an example to describe the educational and technological context in which such a product or service suggests itself. A larger list (which again, by no means exhausts the fare) of products and services is placed at Appendix 2.

Box 1:

Tata ClassEdge:

A company which offers software and hardware solutions in different combinations, suitable for different digital technologies environments. Primarily the components include a projector, speakers, display unit and a control unit.

The software includes curated ‘learning experiences’ which are digital activities, worksheets, videos, simulations, games, quizzes, multimedia, etc. These are based on the ‘Multiple Learning Experiences Model’ developed by the company. All of the content is mapped chapter wise to CBSE, ICSE and some state board curriculum. The software also provides default ‘lesson plans’ to teachers which is the prescribed sequence of ‘learning experiences’ for a particular lesson. Customization of the sequence is allowed. The software also comes with following subject-specific apps/tools that can be used in the classroom:

- Practical: 3d interactive simulations of lab experiments
- Inside Industry: Videos of labs and factories of Tata Group companies to help connect theory to real life applications
- GameEdge: Interactive multimedia games that can be played in class
- Diagram Maker: Step-by-step video guide for drawing diagrams
- Historical Timeline: Interactive timeline showing events related to a chapter in chronological order
- Mind Maps: Shows key concepts of a chapter
- LabEdge: Virtual interactive tools for science and math
- Map Plotter: Virtual plotting on maps
- Whiteboard: Image library of different backgrounds to write on
- ClassEdge Connect is a feature that allows teacher collaboration by connecting teachers of different campuses of a school group. Teachers can create and share resources, lesson plans, notes, etc.

Trainings and workshops on using ClassEdge for teaching are conducted for teachers. Over 25 years since its launch, ClassEdge claims a reach of over 1700 schools[16] ()

8. This has resulted in a glaring absence of differentiation between various competing products. All developers claim their packages to be successful (number of schools, students covered). All of them teach the same topics, basing their flow on the prescribed textbook. Their marketing teams focus on the bells and whistles (gloss, technological conveniences and pricing) rather than content and

[16] https://www.tataclassedge.com/about-overview.html last accessed 29 April, 2022

pedagogical superiority or results of an evaluation.

9. In fact, every product currently in the market, steadfastly refrains itself from discussing impacts. Such products have been around for over three decades. Taken together, however, they do not yet make a compelling case for the necessity of a technology support to teaching-learning.
10. Such EdTech offerings span a wider range of delivery modes today. They are available to be used out of a box in the classroom, they support interactive boards, they are connected to larger sets of resources deployed on the web, they offer support to the administration of teaching-learning (lesson planning, organizing activities, assessment and diagnostics). They have also begun to be deployed online, reaching students beyond the classroom.
11. A similar class of digital curricular support are the online curations of media artefacts. Many of these are also made available as Open Educational Resources (OER) with a suitable creative commons or similar license, aimed at providing free access to the resources. The curation typically attempts to bring together a range of textual, audio-visual and interactive resources aligned to particular subjects, grade level and curricula. Some of these also support community participation in the curation process, which not only enhances a sense of ownership, but the interactions also develop the teacher's confidence and competence in making informed choices.
12. These collections are essentially online. They have a restricted user base, given the limited reach of internet connectivity. The technology developers usually focus attention on the platform and the features of the user interface. Also, they cannot claim expertise in all areas of school education and curation is largely left to the efforts of the users of such groups. Consequently, the collections are broad categories — if one selects a topic, the artefact can span a large range of age groups; if one selects an age group, not all topics are covered. Crowd sourcing the curation process aided by the capabilities of the modern search engines can aid comprehensive mapping up to the concept level. This helps the discovery of resources and perhaps can facilitate greater use by teachers and students.
13. YouTube (https://www.youtube.com/) is a typical example of an open platform hosting a rich collection of videos, produced and hosted in practically all languages of the world. Despite this, however, the limitation of media (YouTube only hosts videos), the absence of limits on duration, a chaotic range of presentation formats (one can present it any which way, as long as it is video), no oversight on content, language and other pedagogically critical factors, makes it rather challenging to align a collection of videos for any teaching-learning situation.
14. Many enthusiastic educators have endeavored to overcome the limitation by creating playlists (curated collections) around various topics and themes of interest. Some producers — individuals as well as institutions, also create videos within a narrow range of content, presentation formats, for a narrow audience and in select languages. Such collections have huge following by users and serve particular purposes of education quite well. In the Indian context, NCERT's channel

(https://www.youtube.com/c/NCERTOFFICIAL/videos) is a large collection aimed at supporting teachers and students.

15. Some services support their video collections through a more comprehensive curation interface in the form of a website. These web interfaces allow for resources in other media formats and interactions. Curriki (http://www.curriki.org/), Merlot (http://www.merlot.org/merlot/index.htm), OER Commons (http://www.oercommons.org/), Gooru (http://gooru.org/), CK12 (http://www.ck12.org/student/) and PHET interactive simulations (https://phet.colorado.edu/) are some typical services hosting Open Educational Resources. Wikipedia, offers a teacher-educator program, to help teachers explore how they can use its content for teaching. The exploration also emphasizes identification of multiple and diverse perspectives and ideas in teaching a topic. Many similar services, which are restricted to paying subscribers are also common. A large number of educational institutions across the world host curricular resources with varying degrees of openness and pricing policies.
16. One open web service, which caught attention of the educators in recent times is the collection of videos by Khan Academy (https://www.khanacademy.org/). Typically aimed at providing tutorial support and concept clarity to a student, the service hosts a library of over 3000 videos covering a range of subjects from arithmetic to physics, finance, and history and skills. See Box 2 below.

Box 2:

Khan Academy: A non-profit that produces short lessons in the form of videos that are hosted on YouTube. The videos display a recording of drawings on an electronic blackboard, which are similar to the style of a teacher giving a lecture. The narrator describes each drawing and how they relate to the material being taught.

The content covers math, science, computing, history, art history, economics, and more, and is aligned with the curriculum of different countries such as the US, India, Mexico and Brazil. The website includes other features such as progress tracking, practice exercises, teaching tools and materials for educators which are meant to be used as a supplement to the videos. For teachers, Khan Academy offers a free course on professional development which explores how Khan Academy can be integrated as part of teaching-learning.

All the content produced (videos and exercises) are licensed under CC-BY-NC-SA.

6.3 Software Applications for Teaching-learning:

1. While most software applications (commercial as well as their FOSS counterparts) used in the school system are adapted from similar industrial and business processes (office suites, graphics and animation software for instance), a few applications specifically made for younger children or for teachers are popular with teachers. Notably, these are mostly FOSS, with a few proprietary

equivalents. Projects like the IT@Schools and initiatives promoting FOSS and OER have attempted to popularize the use of applications like Logo, Scratch (to introduce programing), GeoGebra (as a geometry and simulator), Stellarium (a sky simulator), Google Earth, etc.

2. A large number of teachers who have adopted and explore technologies for teaching-learning form a non-formal community of experimenters. An award scheme initiated by the Ministry of Education; Government of India (known as the National Digital Technologies Award) showcases these experiments each year. A short survey of EdTech products and use by these award-winning teachers was conducted as a part of this report preparation. The survey indicated the use of a varied set of digital technologies devices, software applications and innovative ways of overcoming conventional constraints to reach out to students and enrich their teaching-learning process. A list of the EdTech products used by these teachers is listed in Appendix 2.

6.4 EdTech Products and services reaching out to the student at home

1. As a part of the many variants of EdTech products for curricular support, developers have incorporated an extended outreach to students. Typically, this entails the use of social media and other online interactions to support homework, project activities, etc.
2. During the recent Covid-19 pandemic, the country experienced a shutdown of schools at a scale never experienced before. The forced disruption of classrooms drew the attention of the school system to the possibilities of ICT. Categorized under the umbrella of online learning, a variety of methods were experimented with to keep students and teachers connected. Post Covid-19 disruptions, a range of online communication tools have also found mention (social media apps and virtual conferencing for instance).
3. The various methods tried out highlighted the possibilities of a larger range of technologies use of social media platforms, students using mobile phones, lesson planning involving worksheets and resources being shared, online interactions among students and with teachers, online assessment, alternate scheduling (the standard timetable is normally sacrosanct). Most importantly, it involved teachers in a sudden shift to alternate ways of teaching, not the least, teaching in the presence of incidental observers (parents). Researchers would benefit from studying the range of experiments, issues confronted, solutions discovered, and their collective import for educational transformation and technological support to education.
4. At the same time, the spotlight was turned towards the preparedness of the school system to face such disruptions and leverage technology for the purpose. While those who did have some access to technology grappled with the medium and the methodology, those who could not access technology simply got left out. The stark inequalities in the society were highlighted once more, clearly denying students meaningful access to the teacher and instruction. While it can be demonstrated that

technology can bridge many gaps (the communication gap in the present instance), an aspiration for ubiquitous access to technology for all is currently not a viable proposition. Equitable access to education can be ensured in very many different ways, with and without technology. The search for appropriate solutions, at least, need not begin with making out a case for digital technologies infrastructure and a range of EdTech products and services.

5. Notwithstanding the above, the large size of the EdTech space, has not stopped EdTech developers from perceiving larger opportunities. Leveraging the reach to individual students online is being attempted aggressively. Despite the inequities (technological as well as affordability), which stratify the population into a large number of groups, a sizeable proportion of customers can be found in each group. Based on the enterprise of the developer, unique segments of the population can be served, enabling a simultaneous playing field for many developers.
6. A typical example of an offering of an EdTech solution directly reaching out to students across all ages (pre-school to higher education and high-stake entrance examinations) is Byju's (https://byjus.com/). Launched in 2015, it aims to offer personalized learning programs for classes 1 - 12, and aspirants of competitive exams like JEE, IAS etc. BYJU'S Learning App brings together teachers, technology, content, media and interactions for creating a seamless learning experience customized to and adapting to the individual learning needs of each student. BYJU'S has emerged as India's largest ed-tech company.
7. Incidentally, this development of EdTech developers reaching the student directly, however bypasses the schooling process and throws open a debate about a large number of issues related to existing models of state regulated schooling[17]. Many of the issues are yet to unravel, But the attempts to leverage digital technologies in this manner will need to be viewed very closely and critically.
8. Beginning as a tutorial model, providing extra support to the student, particularly in preparing for competitive examinations, such services competed with the parallel universe of tutorial classes. The tuition industry quickly adapted to the possibilities and today a continuous range of offline, offline supported by technology products, offline supported by online, and purely online co-exist. This has provided a wide range of choice suited to different wallet sizes (affordability).
9. Buoyed by the success and aided by the fears of exclusion during the Covid-19 lockdown of schools, the online offerings have expanded to lower classes, all the way down to pre-school and primary classes. Ethical and health issues related to very young children exposed to small screens for an extended duration of time are yet to be addressed. Also, EdTech products have remained outside public scrutiny. Issues related to content, methods and their socio-emotional impacts will have to be addressed too.

[17]They may even clearly violate many provisions of the RTE.

6.5 EdTech Products in the larger School System

1. Schools are engaged in a variety of administrative and managerial functions. Governance of schools by state authorities also required data interchange and communication. Like any other business, many of these functions are progressively being automated. Typically, one encounters automation of accounting, stores and inventory, communication, documentation and record keeping. Typical academic activities like management of resources (library automation, for instance), time and task management and examinations have also found digital technologies support.
2. While the instances of specialized software applications for these processes are fewer, a growing list of customizable products which aim to encompass various administrative and managerial functions into a common interface, which can be used by a varied set of users like school heads, administration personnel, teachers, students, and parents are available. Typically going by the generic name of School Management System, these products range from simple web portals hosted locally to elaborate cloud-based applications servicing a variety of devices and connectivity. While the benefits of such automation are readily visible, the technological preparedness of the system has to be rather high as it involves seamless use by a variety of personnel. It also requires a wider deployment of infrastructure across the school. Consequently, such solutions have typically attracted the attention of larger private schools.
3. Boards of School Education, administrative head offices of larger networks of schools and other state authorities have been progressively moving typical paper transactions into automated and now online transactions, improving record and data handling and system efficiency. Automation of large-scale examination results management is a good example of digital technologies enabled transformations.
4. The greatest benefit of such automation is the establishment of transparent processes and informed decision making. The infusion of technology can catalyze these processes but the transformation of the system's expectations and preparedness will be a major determinant of the benefits that digital technologies can enable.
5. Consider, for instance, the availability of school dashboards supported by a large-scale online information system, the school's geo portal at https://schoolgis.nic.in/. Supported by suitable filters and data mining features, the data can be repurposed for a wide variety of administrative and public information services. Assessment of gaps in infrastructure and facilities, identification of training needs, etc. Decision-making at the local educational authority, say district technologies level can be supported. Publication of such repurposed data also enables community debate, appraisal and enhance their participation in school development activities.

Conclusions

1. Modern day Information and Communications have distinguished themselves and are rapidly becoming part of daily life. Ready availability, affordability and the convenience of operations has greatly contributed to its popularity. Its ability to support multiple media, facilitate instantaneous communication, store and retrieve huge amounts of information and enhance efficiencies and productivity in a variety of industrial and business processes, makes it a technology of choice.
2. Attempts have been made to explore the possibility of infusing these technologies into educational processes too. Three major strands of applications can be noted — the use of digital technologies for learning to compute; support teaching-learning, particularly in the classroom; and for automation of administration and communication. The adoption of digital technologies for one or more of these applications is still limited to a small proportion of schools and even there, a limited set of devices used for a limited set of purposes. The sub-optimal use of digital technologies may largely be attributed to the cost —to initially establish it, maintain it, and regularly upgrade it.
3. The scattered and minimal infusion also exhibits enormous diversity both in terms of quantity and quality of the infusion. There are no apparent patterns in the distribution across states, types of schools, geographies, socio-economic conditions — digital technologies have failed to catch the imagination of the school system. This points to an absence of a clear appreciation of what digital technologies can offer to the teaching-learning process. To an extent the other strands — learning to compute and office automation appear to be better appreciated, though they too are under-utilized.
4. Digital technologies products and services have been developed and tried out, spanning a range of educational applications like teaching, assessment, school administration and communication. Wider services like online portals, management information systems, repositories of content resources, online courses have also been experimented with it. The participation of the education community in the design and development of such products, however have been usually limited to being passive consumers.
5. The schooling process in India is strictly regulated and prescribed, particularly with reference to curricular processes, the authorities have not attempted to mandate the use of ICT. Schools are generally free to design their response to ICT. Curricular resources developed by the NCERT and the states do not yet take note of digital technologies possibilities — a typical description or explanation in a textbook does not require the use of digital technologies. (Some developments have begun to emerge in the form of links to web resources or collections of digital resources accompanying the printed texts). Teachers are not being expected to train themselves and explore the use of digital technologies (again, many pockets of digital technologies use by teachers, catalyzed by various agencies have emerged).
6. Research into the use of digital technologies is limited. In particular, evaluation of different models of

digital technologies used in the classrooms and by teachers and students individually are very few. Seeking support from research to justify design, plan, or investments in digital technologies infrastructure or the choice of educational applications is difficult. One of the factors' inhibiting research is perhaps due to the fact that a majority of EdTech products and services are in the private domain and are not available for rigorous evaluation, leave alone comparison. The need for informed choices of digital technologies resources can only be made through changing this situation.

7. State participation in the appreciation of the potential and the relative effects of different EdTech products and services will go a long way in establishing a mainstream demand for exploration of the possibilities, research and evaluation and widespread use. States will also be required to enable and promote localization as a majority of schools function in the State languages. A free-market paradigm will neither encourage the developer to attempt digital resources in Indian languages, nor will it be economically feasible. State sponsored programs which draw upon the technical expertise of the private sector, and incubate a variety of applications can expand the use of digital technologies in the school system.
8. The development of multipurpose technology highways for promoting digital technologies use is needed. Consider for instance the digitalization of information and data emerging out of the schools and its utilization in informed decision making. Extending on the models available — online board results, online admissions and selections, management information systems — it is possible to develop a comprehensive end-to-end solution which enables all stakeholders to participate in generating, populating, accessing and making use of the data. Similar solutions for large scale repositories of curricular resources and online course platforms to support continuous professional development can enhance productivity and efficiency, alongside catalyzing the development of digital technologies infrastructure and a culture of digital technologies use.
9. The capacity of teachers to innovate in education and define directions for digital technologies developments has remained an untapped potential. The result is a continuing disconnect between developments in educational theory and expectations and what digital technologies products and services offer. Students, teachers, and schools have to remain content with products and services, which may not be best suited to overcome the limitations of their existing practices.
10. The creation of a large canvas encompassing a large number of schools provides opportunities for research and testing of various newer technologies at scale. The present paradigm of an individual school as the unit for digital technologies applications distracts the initiative into marketing efforts, away from improvements to the products themselves. Technological possibilities like personalized learning (adopting Big Data/ Machine Learning / Artificial Intelligence) are feasible only at large scale.
11. For the private developer seeking business opportunities and for philanthropic projects in ICT, the segmented school system will continue to be the overall complexion of the landscape. And till the

canvas is consolidated and an enabling environment developed as described above, the enterprise and creativity of a few individuals and organizations will continue to function as a bridge between educational practice and ICT. The future of digital technologies clearly lies in an aspiration for better education. The larger transformation of schooling practices fueled by innovations in digital technologies will have to wait. And if the exploration, research and demonstration of digital technologies do not result in a well-supported educational model for the integration of ICT, it may not live up to its promise.

Appendix 1: The Utility of Geographical Paradigm of a Landscape to Situate Digital Technologies in Education

A geographical landscape consists of a terrain (a substrate) which is influenced and transformed by a variety of forces. These forces include geological, climatic and human forces. Geological forces act over very long periods of time, soil erosion for example. Some geological forces also act suddenly, an earthquake for example. Climatic forces can be seasonal, changes in weather, flowering or migrations of birds for example. They can also be non-seasonal variations, cyclones or floods for example. Human interventions cause changes to the landscape as in the development of human settlements, constructions for example or in the exploitation of natural resources, mining for example.

Together, these forces change the landscape in the long term or short term, permanently or temporarily, or even irretrievably (humans cannot restore the change). The changing elements, the cause of the changes and the nature of changes are equally significant to an understanding of the landscape.

Except for a few human mediated changes, most changes to the landscape are beyond our control; we can only react or respond to it. Of course, human ingenuity has helped understand some changes, anticipate them and initiate responses in advance to mitigate the consequences of the change.

When we observe a landscape, we are perceiving a snapshot of the landscape and any inferences of the direction or magnitude of the changes are due to and limited by our ability to extrapolate our observations.

The height from which we observe the landscape defines the zoom level and therefore our ability to resolve details. What appears as a green mass from a particular height may resolve into deciduous forests, evergreen forests or even grasslands. At a lower height, they may result in a view of trees, shrubs and perhaps barren spaces in between.

The idea is to appreciate the fact that our ability to locate ourselves at a particular zoom level and extrapolate to other zoom levels would be limited. Focusing on the details at a particular zoom level would also result in *missing the wood for the trees.*

The use of this geographical analogy to analyze processes in the school system is particularly relevant as the dispersed and diverse school system could well be constrained by a top-down planning effort for a situation which deserves the exact opposite.

Zooming in and out enables us to observe the situation from different distances from the point of action. In the present context – visualizing digital technologies for the school system, let us begin at a level where we perceive the entire schooling system as a whole (arbitrarily referred to as zoom level 1). The fact that there exists a common structure, a common curriculum and a common examination process at the end, across all schools in the country gives us a semblance of a homogeneity. A one size fit all visualization of digital technologies is suggested. A computer lab with an appropriate number of computer stations, an digital technologies education curriculum spanning multiple stages of schooling; classrooms equipped with projection systems to support the transaction of teaching-learning; an academic management information system which can track student achievement, generate feedback, and communicate the same to all concerned; an administrative management information system which enables the automation of administrative processes; and finally web services which support all of these functions. In fact, there exists a number of EdTech products and services which together attempt to serve these applications.

Going closer, at zoom level 2, we begin to perceive granularity. There are schools run by various agencies of the Central Government, schools affiliated to the various national boards. Every state has its own system of public education and provisions for private participation; the regulatory systems change; minor variations in structure emerge; state and local languages become mediums of instruction; variations in curricular resources emerge; and together these result in schools of all sizes, facilities, capabilities, quality of services. In terms of ICT, this situation already reveals constraints of all kinds — digital technologies infrastructure, support infrastructure (rooms and electricity), appreciation of what digital technologies can do, teacher quality and readiness to use ICT, and availability of appropriate digital technologies applications (and in local languages). While prescriptions for computer education and digital technologies in administration would perhaps remain the same, the same is not true for digital technologies in teaching-learning.

Going even closer, at zoom level 3, we begin to distinguish differences in subjects and their methodology, relative weights attached to these, different approaches followed in the syllabi and textbooks, and inter teacher differences in teaching and learning. What happens in primary classes is different from the upper primary and the high school classes even within the same subject. For digital technologies to be able to support these variations, an element of flexibility must exist, teachers should be able to customize the use to their subjects at the level they are teaching and the range of activities they wish to perform.

Designing curricular packages which meet this complexity, while still conforming to common technological templates becomes difficult; fewer products and services which attempt these are available. But achieving a balance between a technologically sound product, which simultaneously provides the teacher a freedom to customize is a tight rope walk indeed. Many existing products manage to become prescriptive, eroding teacher agency in the use of ICT.

In fact, there exists a still deeper level (zoom level 4) at which there are individual lessons — each chapter is transacted as many lessons, and there can be many distinct types — and a small group of children to whom these are delivered. Ideally at this level, the landscape resolves into individual geographical elements —

every 45-minute session is different (and has many parts too), every child is different. Extrapolated across up to zoom level 1, the complexity rivals any long exposure night sky photograph. ICT, except perhaps in the most generic sense — provide a computing device of choice with an internet connectivity and leave the teacher to her own ways, is primed for underutilization, minimal impact, and become a big distraction.

This is not to argue the futility of designing digital technologies for such scenarios, but to plead for a bottom-up design. Every child must benefit from its investments of time and effort into schooling; every teacher should be able to provide for these opportunities. Any meaningful use of digital technologies should address education from this vantage, cumulating the components upwards. Given the diversity of the schooling landscape, what is likely to emerge is a bouquet of options, perhaps even a choice of individual components, which can be brought together to serve a particular case.

Appendix 2: List of EdTech products and services used by the teachers surveyed

https://tinyurl.com/EdTech-products-list

KERALA Information Technology for Education (KITE)

Kerala KITE has several initiatives for using EdTech for academic and administrative activities. These programs are different from the student-centered/ content-focused commercial offerings. They focus on strengthening the role of the teacher (by having technology mediated through the teacher and not by outsourced parties/vendors), strengthening the public school system, through a comprehensive use for academic and administrative, rather than focus purely on classroom transactions.

Kerala has implemented a school management system in all high schools across the state, through the Samagra platform, to support school administration.

The Kerala IT@School program introduced 'subject-specific' software applications (FOSS) in different subjects, generic resource editors and focused on building teacher capacities in using these tools for making materials and for teaching. A list of these tools used in the Kerala program is provided below

Subject Area	FOSS applications
Language	K Anagram
Mathematics	GeoGebra, LibreOffice Calc, Turtle Blocks
Science	Phet, Kalzium, Stellarium, Avogadro
Social Science	Marble, K Geography
Image editor (Art)	GIMP, Inkscape
Audio editor (Music, language)	Audacity
Video editor	Kdenlive
Animation editor	Peek

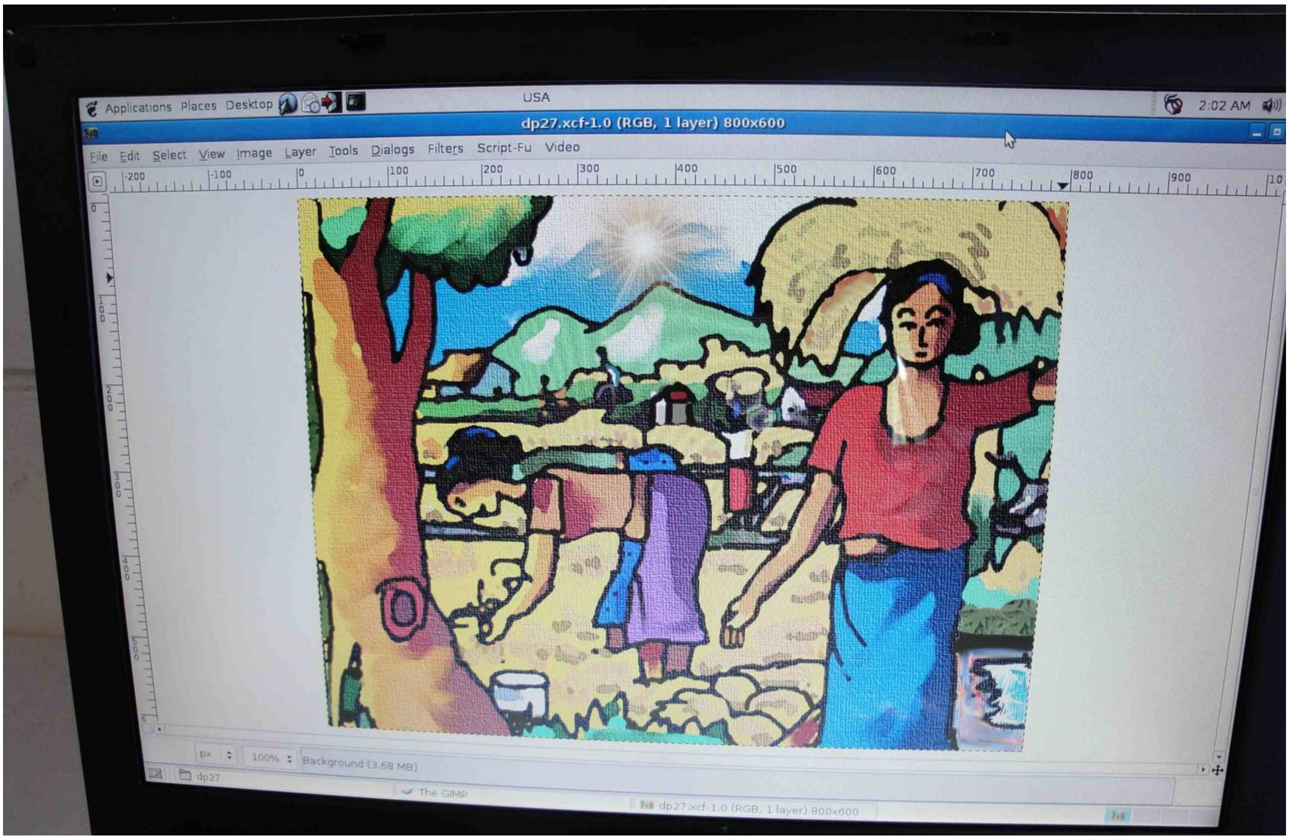


Figure 1: Kerala Student Digital Art state wide competition, in 2010, indicates that the digital technology integration has moved beyond mathematics/science kind of core subjects.

KITE has also developed cloud base services for schools and teachers and students, such as the online language lab. It has an inhouse software development team that has created an off-line English Language Lab (ELL), using the Moodle FOSS platform.-It has established a MediaWiki FOSS cloud platform to allow each and every school in the state to have their own website.

They also have programs for ongoing teacher development to support them in using digital technologies. Workshops are conducted every year, coordinated at the district level by district centers established by KITE in every district of Kerala. District level establishment of Educational Technology service centers is perhaps unique to Kerala.

Programs are also conducted for other stakeholders — such as cyber security awareness programs for parents/mothers, grama panchayat members etc.

Having a strong and independent institution such as KITE to plan, design, implement education technology programs in the state on a continuous and sustained basis. It enables the state to keep investing and incrementally benefiting from every investment. This is in contrast to the large point in time investments that do not add up / are not made to add up, in most other states of India. While each program, even with a huge investment can peter out over time (as explained earlier, due to hardware and software obsolescence and failure), in Kerala, the continuity in investment, the availability of a team to provide support and teacher development has enabled the school system to sustain technology integration. The absence of vendors providing educational services at the school level, or even of NGOs providing such services (instead relying wholly on teachers), has also, over time, developed a stronger sense of ownership of the school and the teachers over the program.

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They can be accessed from the ITfC website: https://www.itforchange.net/publications