Education Technology for School and Teacher Education

(*position paper for the implementation of the NEP2020*)

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Executive Summary

A1 The Universal goal of education is to support the growth of children into sensitive, capable and responsible citizens of the world.

A2 Schooling has emerged as the preferred societal response to this need; delivering education consists of inspiring and enabling children to learn, implying a focus on development of faculties and habits of learning – *learning to learn*, enabling the acquisition of knowledge and skills, and development of a personality suited to the roles and responsibilities children are being groomed into.

A3. With the aim of scaling up to reach larger and larger numbers, schooling has grown into a complex enterprise with a variety of component activities and processes. Each of these activities and processes have also acquired their own structure and preferred ways of functioning. The unique component systems and their interrelationships constitute the technology of education.

B1. It is a constant endeavour of all enterprises to seek newer technological solutions to improve their functioning, enhance their efficiencies and productivity.

B2. Modern day information and communication technologies have shown great promise and consequently raised expectations.

B3. Experiments with various technology solutions to address educational problems have resulted in an increased general awareness of the possibilities; an awareness of the challenge of integrating modern ICT; and a heightened aspiration. This is evidenced by the recommendations in the NEP 2020 and the state's endeavour to explore the possibilities.

B4. Modern ICT have made successful inroads into various walks of life fuelled by easy and affordable access to devices, applications and connectivity. In particular, the successful integration of ICT into similarly complex enterprises has lessons to offer on the choices of technology and the modalities of implementation.

C1. The schooling enterprise can be classified into three broad areas:

- the overall administration and management ranging from the individual school to the state education system level;
- the capacities of teachers and other personnel at all levels; and
- the teaching-learning processes

C2. Modern ICT hold the potential of supporting each of these areas. Accordingly, this paper proposes three broad categories of ICT integration, viz.,

- Data and Information Management System
- Continuous Professional Development System
- Curricular Support System

C3. This classification attempts to address the integration of ICT into the schooling process aimed at progressively carving out time and space for schools to focus on their core purpose – enabling children's learning.

C4. The Data and Information Management System suggests the comprehensive automation of all layers of administration. The seamless integration of data, its analysis and the generation of a variety of data products in order to enable and support a culture of *informed decision making*.

C5. The Continuous Professional Development System holds the potential of keeping all personnel, particularly teachers at various levels, up to date and well informed of the developments in their field, constantly upskilling them. The professional development can take the form of online courses and also communities of practice, technologically mediated forums of teachers, for instance, sharing insights and hand holding each other.

C6. The Curricular Support System provides the enrichment required to drive the teaching-learning process to higher levels of cognitive engagement. This is expected to accelerate the growth of children's capacities to learn, transforming them into independent learners better equipped to benefit from the opportunities that will become available to them.

C7. Together, these three categories of ICT integration can catalyse the very foundation of schooling – equitable access to a holistic education and help develop a citizenry ready to take on the challenges of adult life and modern society.

D1. Beginning with the initiatives following the National Policy of Education (NEP 1986, modified 1992), the State has invested on a variety of experiments to explore the possibilities of ICT in improving schooling. These experiments have generally been reactive in nature, basing the experiment on available technological devices and applications. Consequently, many of these experiments have been superseded by technological advances and obsolescence of the products. The runaway evolution of technology could not have been anticipated and systemic constraints have inhibited the education system from keeping pace. However, this phase of experimentation – *a Phase 1.0*, has important lessons to offer and can guide the next phase of ICT implementations.

D2. The position paper proposes the next phase of ICT integration into education – *a Phase 2.0*, the distinguishing feature being a comprehensive re-imagination of the educational process, with ICT tightly integrated with the design of all relevant processes. The *a priori* assumption of access to ICT is expected to transform the very methods of functioning.

D3. Such a re-imagination requires ICT to be treated as an end to end solution. All components across the entire chain will have to assume access to ICT and modify themselves accordingly. For instance, when applied to the curricular process, the curriculum, the syllabi, the textbooks and other resources, the lesson planning, the teaching-learning methods and evaluation will all have to be informed and be transformed accordingly to optimise the benefits of ICT integration.

E1. The capabilities and resources available will have a bearing on the extent to which such transformation can be visualised and initiated. The biggest bottleneck in ICT has always been the deployment and management of the infrastructure. Phase 1.0 experimentation suffered from the limitations of the technology prevailing at different points in time. Continuing with the primary goal of computer literacy, a model of computer laboratories consisting of stand alone or networked

desktop computers with a range of general purpose software applications constituted the general ICT infrastructure. This set up can be shown to serve limited purposes, along with constraining timely access for the range of purposes a school could put ICT to.

E2. With the evolution of ICT over the years, the establishment of internet as the *defacto* channel of communication, easy and affordable access to a variety of computational and communication devices, and the emergence of smart phones as the preferred personal device has come to define modern ICT. Fortunately, it is possible today to conceive of ICT infrastructure differently.

E3. The position paper proposes a minimalist technology infrastructure, with an emphasis on a dependable end to end connectivity – online and offline, synchronous and asynchronous – and support for a variety of personal devices connecting to the backbone in and outside the school. Strategies for providing access devices to the end users are described.

E4. The deployment of the proposed solutions for data, training and curricular resources, supported by a range of appropriate software applications, all deployed on the cloud, will reduce the demands on the user devices. The increased use of personal devices is also expected to enhance the sense of ownership and contribute to increased participation. The design of the solutions will go a long way in helping the end user see purpose in participating and progressively take ownership of the solution.

F1. The re-imagination of the educational process in order to integrate and benefit from an ICT enriched environment constitutes the major thrust of the recommendations. It must be noted that in the absence of a comprehensive transformation, the initiative is likely to outsource the running of a constrained system to technology and as has been seen time and again, technology aggravates the faults.

F2. The re-imagination begins with an identification of all relevant components, activities and processes; evolution of a road map for their transformation; assessment of readiness in terms of human resources, operations, technology and financial support; establishing a time bound and phased out roll out plan; and the development of a constant monitoring, evaluation and feedback channel.

F3. The proposed transformations will require a wide range of expertise, specialised know-how and skills. There is a need to identify and upskill people from within the system; not only will this result in an investment on human resources development, but will also enhance ownership. However, creating an open interface to facilitate the participation of expertise from outside will expand the range and scope of the implementation, while enhancing public interest in the endeavour.

G1. The position paper makes detailed recommendations about the strategies for each of the three strands of ICT integration proposed. These include suggestions for:

- Envisioning the plan and roadmap;
- Establishing the system, processes and personnel;
- Establishing the technology;
- Evolving timelines and targets; and
- Identifying key process indicators and evaluating outcomes.

1.0 Introduction

1.1 Nature and Scope of Educational Technology – An Overview

Education is the process of building the capabilities of individuals. Every society endeavours to provide opportunities to its children to acquire those capabilities. This enables them to perform their chosen role and be a productive citizen of the society. The cumulative aspirations of society constitute the aims of education. These include the kind of society they wish to develop into and the kind of people they wish to nurture in order to take on the responsibility of leading the change. History points to the fact that wise and knowledgeable persons of the community were called upon to take on the responsibility of nurturing the young.

Over the past few centuries, *Education of the young* has evolved into a systematised and formalised system we refer to as Schooling[1]. It is now universally accepted that equitable access to education is a right of each individual. The enterprise of education has therefore grown to gigantic proportions. The system has also become complex and acquired a large number of distinct characteristics. The most significant of these characteristics is the *Technology* deployed to operate the system. Curricula, syllabi, teachers, classrooms, age-wise stratification of children into grades, progression of children through the grades and a wide variety of tools, techniques and processes together constitute the *technology of education*. While it is uncommon to refer to timetables, or blackboards or examinations as technology[2], these components are expected to aid efficiency and productivity of the system.

As newer and newer technologies emerge, their potential to support, extend and replace existing practices are explored. Some prove to be successful and establish themselves into the mainstream concept of education. Perhaps fifty years from now some of the present day information and communication technologies would have been incorporated into the standard practice of education, say for example the use of internet to network with students in order to provide them support beyond the classroom.

Children begin their journey in education very young, when their capabilities to learn are still being developed. As they grow older, these capabilities increase, enabling them to actively participate and make choices for their education. From an understanding of how these capabilities develop, it has become possible to align the content and process of education to suit the needs of children. *The success of any new technology has to be measured therefore in how it contributes to serve this purpose.* Technologies may directly aid learning by children; they may aid the teacher in improving the learning experience or make it easier for her; they may alleviate her from the burden of extraneous tasks like record keeping; they may also help in administration and governance of the overall system.

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1 The two terms, schooling and education are commonly conflated and used interchangeably. In order to avoid confusion, therefore, this document will use the term education to refer to both, the process (schooling) and the aims (education), urging the reader to recognise the distinction from the context.

2 “Technology is defined as the application of scientific knowledge for practical purposes and as machinery and equipment developed from the application of scientific knowledge.” source: Oxford Languages, Oxford University Press, 2022.

Serhat Kurt defines *Educational technology* as a field of study that investigates the process of analysing, designing, developing, implementing, and evaluating the instructional environment and learning materials in order to improve teaching and learning[3]. In the analysis that this position paper attempts, a slightly broader context of education is considered. This includes:

- not only the classroom, but also the whole school, school district, and the entire state;
- not only the teaching-learning process, but the resources, training, and support systems;
- not only the day-to-day management of data, but also an end-to-end data pipeline which can enable informed decision making at all levels.

When does a technology gain acceptance? What characteristics indicate the potential for its future success? The acceptance and integration of a particular device, process or tool depends on how well the technology addresses specific pain points and demonstrates its utility in the educational process. Apart from an explicit advantage over prevailing practices, it must be easy to use, have a short learning curve enabling everyone to adapt it and dependable. In the long run, however, a comparison of the investments of time, effort and cost needed to integrate this technology against the benefits it can yield become critical[4]. For instance, despite the demonstrable advantages of a library or audio-visual projections or the use of computers, there are indicators of extremely low usage of these technologies in schools, particularly in classroom teaching.

The aspirations for the use of technology should also find popular support from among fellow colleagues. Many an innovative and interested teacher has found it difficult to swim against the tide and has given up. In a typical State run school system, these are compounded by issues of budgetary allocation, complexity of processes involved in large scale rollouts, choices of technology and evolution of a consensus between the implementer and the end users in terms of the scope and use of the technology.

The recent pandemic induced disruptions are a case in point. The apparent inevitability of using technology based channels pushed students and teachers alike into exploring online communication for teaching-learning. Despite the sustained exposure, however, it is unlikely to be considered in mainstream schooling, once schools resume. The learnings from the experience have been very diverse and may not translate into a confidence in the technology to supplement teaching-learning. The common understanding of the role of teachers and students in the teaching-learning process does not require technology support (typically, a teacher is happy being *a sage on the stage*); and the broader possibilities of a technology enabled classroom are not demanded by the system[5]. In order that technology continues to be seen as a positive contributor in the post-pandemic situation, transformations in expectations from teaching-learning is perhaps the most important step. This should be followed by enabling environments (both physical and technological), and a reasonable assurance that no student is left behind due to an inability to access a device or connectivity.

It is the central thesis of this position paper that beyond the point of demonstrating the utility or benefits of particular technologies, it is necessary to make them an integral part of the educational

3 From Educational Technology: An Overview, https://educationaltechnology.net/educational-technology-an-overview/, by Dr. Serhat Kurt, accessed on 10 December, 2021.

4 This analysis will be revisited in section 3.2 below to examine why potentially good technologies have failed to establish themselves and to suggest a framework for the selection of appropriate technologies for different aspects of the educational process.

5 Hopefully, the aspirations of the New Education Policy will help incorporate an expanded view of teachers, teaching, students and learning.

process. *Conceiving a range of technologies and associated processes as parts of an end-to-end solution for the school system holds the best promise for their infusion and integration.* This will call for identifying all components, persons and processes that are likely to influence or be influenced by the roll out of the technology. More importantly, this will require a constant evaluation and realignment about how well the technologies taken together or separately contribute to increased efficiency and productivity of the system, particularly in enhancing student attainment. As is evidenced by the partial successes of various ET/ICT experiments conducted over the years in Karnataka (and even elsewhere), despite the best intentions, the solutions tend to become part solutions to part of the problem they seek to address.

The generally high level of infusion of technologies across various day-to-day activities have heightened the general awareness of people about the possibilities. The pandemic disruptions have also performed a useful role in catalysing these expectations. The time is perhaps ripe to consolidate the efforts made over the years, leverage the leanings in the New Education Policy towards establishing a robust system of education, responsive to its core goals of holistic development of each child, and in a very generic way integrate select and appropriate technologies.

2.0 The Context

2.1 An overview of present implementations, plans and provisions for ET

Karnataka is ahead of many states in its Digital initiatives in the spaces of IT education, IT enabled education and IT for administration. The state began very early with the implementation of the New Education Policy of 1986, through the CLASS project, use of EDUSAT, the Mahiti Sindhu project, the ET scheme (later, the ICT scheme) and recent initiatives of large scale data compilation and analysis as well as online learning. A timeline of the initiatives is placed as an Appendix.

Broadly, the ET/IT/ICT initiatives can be classified as under:

- Provision of infrastructure, both hardware and software in schools, DIET, CTE;
- Development and dissemination of e-content, audio-visual content resources, including broadcast;
- Training of teachers in ET/IT/ICT; Training of teachers in other areas using ET/IT/ICT;
- IT/ICT for school system administration and data applications;
- Development of websites, web interfaces, online apps

What are the learnings from these efforts? What directions do they offer for future implementations and integration of technology solutions into education?

- A culture of innovation and exploration of newer possibilities is well established in the State;
- The Department of Education has initiated many experiments and organised training for teachers and administrative personnel in the use of technology;
- Consequently a large number of functionaries have been exposed to the possibilities of technology;
- Some of these initiatives have been mainstreamed and are good examples of need based technology solutions (the online teacher transfer system, the organisation of CET counselling, etc.);

- School level implementations have focussed on computer education (now expanded to ICT education) and do not adequately support ICT enabled education in other areas of the school curriculum; also, they do not span all levels of education;
- ICT enabled activities require support beyond the provision of hardware and software and the requisite platforms have not become available;
- A universal technological support base (infrastructure, system readiness and training) is not available for leveraging large scale interventions and reforms;
- Most of these efforts have been programme based and have remained confined to smaller segments of the system and have even been discontinued following the closure of the support provisions;
- Taken together, the initiatives do not span the entire school and teacher education system, leading to discontinuities and disruptions;

The efforts have generally been a response to emerging technologies. And many of these technologies have been short-lived or at least proved to have limited effects. The dangers of accumulating hardware and software which rapidly become obsolete or lose compatibility with their newer cousins are immense. The emergence of cloud based deployment of platforms, including online software, suggests a leaning away from large investments on infrastructure at the user end. The convergence of mobile devices and conventional computing devices and their seamless use of the internet portends well for conceiving an information and computing highway connecting all the component nodes of the education system at all levels. The connectivity can be designed to be device agnostic and location independent, which in turn facilitates better reach and improved interactions.

As suggested in section 1 above, conceptualising an end-to-end reform in education, maximising the potential of modern day information and communication technologies calls for a consolidation of the efforts and reimagining the system. In order that technology solutions do not become temporary fixes and the absence of continuity does not fritter away the gains, attention is called towards the following:

- A critical research and documentation component is integrated into each of the experiments and initiatives;
- The outcomes and the limitations recognised are shared with all potential stakeholders across the system and taken note of, in course correction and designing similar interventions;
- The establishment, management and sustenance of an information technology system requires the support of a specialised and suitably equipped team, dedicated to the purpose[6];
- The needs of the system can be broadly classified into: curricular support; professional development; data and information system;
- Each of these sub-systems require the evolution of a comprehensive plan involving the conceptualisation, design, administrative and technological framework, an ownership design (roles and responsibilities) and roadmaps for their effective establishment and rollout[7];

6 A case analysis of the working of a system like the CET counselling will showcase the need for information, technology and communication teams, synergising their efforts under an overall plan; any large and complex business operation deploys specialised teams under an information officer (CIO)and a technology officer (CTO) alleviating the burden of the users and consequent enhancement of their efficiencies.

7 The details of these plans are discussed in section 3 below.

- Placing the educational or system needs as the central purpose and relegating the availability and arrangement of the hardware and software to their due role as a support system, results in better project outcomes.

2.2 Perspective of NEP2020

It is interesting to note that while the 1968 policy made no mention of Educational Technology (in fact it did not refer to classroom processes at all), the 1986 policy focussed on the use of then prevalent technologies – radio, audio-video, broadcast and film/slide projectors. The training programmes to inform stakeholders about the policy (Programme of Mass Orientation of School Teachers and Operation Blackboard) also experimented with video conferencing as a means to reach out to teachers. The specific focus was on assisting teaching-learning and improving schooling processes.

Since then, there have been rapid developments in the field of ICT. There is widespread use of the technology in a variety of fields, a ubiquitous access (although some geographical and economic constraints persist) to devices and connectivity through the internet and a heightened awareness of the possibilities of individual devices. These developments have also prompted the development of a large number of software applications and platforms supporting a variety of educational activities. The rather cliched slogan of *anytime anywhere access* does not appear improbable. This applies not only to devices and internet connectivity, but also to a variety of services, which have the potential to transform access to education; consider for instance, digital data warehouses or online course platforms.

It is in this context that the recommendations of the New Education Policy, 2020, should be considered.

Continuing with the focus on supporting teaching-learning and improving the schooling processes, the NEP has articulated its aspirations and proposals from modern information and communication technologies. Spelt out across two sections, Technology Use and Integration (sections 23.1 – 23.13) and Online and Digital Education: Ensuring Equitable Use of Technology (sections 24.1 – 24.4a), the NEP reiterates the role technology can play in:

- improvement of educational processes and outcomes;
- supporting teacher preparation and professional development;
- enhancing educational access; and
- streamlining educational planning, management, and administration.

It recognises that technology can influence not just what students learn in the classroom but also how they learn. At the same time, it warns the educational system from trivial usages of technology which excessively burden students with factual and procedural knowledge, at the expense of developing their higher-order competencies.

It proposes a focus on:

- training and incentives for teachers to become high-quality online content creators;
- use of online teaching platforms and tools by teachers for their own upgradation;
- design and implementation of assessment frameworks; and

- research and validation of technology tools and resources.

The NEP proposes research into the potential of online and digital technologies to reach quality education to the unreached and difficult to reach. It proposes to share the results of these studies publicly to facilitate continuous improvement. It also recognises the need to raise awareness on issues of privacy, laws, and standards.

The NEP proposes to invest in the creation of an open, interoperable, evolvable and public digital infrastructure in the education sector[8] that can be used by multiple platforms and point solutions, to solve for India's scale, diversity, complexity and device penetration. This infrastructure will support:

- appropriate existing e-learning platforms;
- development of a rich variety of educational software for students and teachers at all levels;
- content creation and a digital repository of content;
- leveraging of existing mass media, such as television, radio, and community radio; and
- creation of virtual labs for practical and hands-on experiment-based learning experiences.

3.0 Concerns and Challenges

3.1 Concerns and Challenges of Education

Reference was made in section 1.1 above to the enterprise of education as a formal structure developed by society to nurture its young. Continuing with this concept, it is noted that any technology will have to demonstrate its utility in addressing one or more of the issues affecting the operation and efficiency of the education system, particularly in enhancing the prospects of better reaching every student and enabling their attainments.

This section attempts to analyse the educational system in order to identify the various sub-systems and components and appreciate the relationships they have with each other. Such an analysis aids the consideration of problems, their causes, probable solutions and the potential of technology devices and processes to redress them.

The education system caters to students across a wide age range. At the lowest end they are infants, just out of the confines of their homes. At the other end, they are ready to be declared adults and rearing to take on their responsibilities as citizens of the society. The cognitive, socio-emotional and psychomotor developments across this range are also not uniform. Each child is different, growing differently, and consequently having varying needs. These differences are further aggravated by extraneous influences in the home, neighbourhood, media exposures and adult interactions, which again are not uniform. The psychological development across this range represents a major challenge for the conceptualisation of curricula, resources, methods and arrangements.

The domains of knowledge included in the school syllabi as subjects of study, form the medium through which various capabilities of students are developed. What syllabi are relevant at different stages of schooling – primary, middle, secondary and senior secondary is governed by the

8 National Digitial Education Architecture (NDEAR), Department of School Education and Literacy, Ministry of Education, Government of India, 2021

developmental needs of students at these stages. The nature of these domains and the specific stage at which they are taught also have implications for development of textbooks and other curricular resources, preparation of teachers, choices of methods and technology resources.

The education system has developed into a very complex system, with multiple layers of functionaries, working on different sub-systems using a variety of tools and devices. While some interact directly with the beneficiaries – the students, say for instance teaching or examinations, some interact remotely – the development of textbooks or training of teachers. Some other sub-systems are completely extraneous to the students, but influence their attainment, say for instance the timetable or transfer of teachers.

Each of these sub-systems are also complex on their own, involve a variety of functionaries at different levels. Keeping the central purpose in focus, while developing resources throws additional challenges. Consider the two cases presented below – the evaluation system and development of textbooks[9].

Case 1: The Evaluation system

Evaluation constitutes the making of a judgement about the amount, number or value of something

In education, evaluation has come to be conflated with a variety of other nouns – assessment, tests, examinations, etc. The natural question to ask when tasked with the responsibility to evaluate is to ask, *evaluate what*?

The purpose of teaching-learning is the development of one or more abilities in each student, say for instance, learning to articulate one's thoughts. The particular activities organised for the purpose (an opportunity for the child to express), the organising of the activity (teaching methods), the curricular resource (a drama in the language textbook). The ability to speak is also a function of the number of times it is practised and the feedback given to the student.

Evaluation therefore has to ask questions of each of these – how effective was the experience provided? Was the practice adequate to develop the ability? how relevant was the feedback provided? How suitable was the textual material? Did the reading ability of the student interfere with the outcome?

Evaluation involves selecting an appropriate tool and the measures, making relevant observations or measurements, assessing and obtaining results and finally interpreting the results. The interpretation helps in corrections to any or all of the sub-components. While some of the interpretations apply to the student's effort, some others apply to the teacher's effort and others to the materials, methods and resources used.

When evaluation is conflated with examinations and reduced to a written test (as is usually the case in schools), it fails to measure any of the relevant factors (skill of expression, teacher abilities, activities and methods, materials and resources).

Invocation of a technology support, say automation of the testing process, only results in compounding the limitations of the evaluation process.

9 Textbooks themselves are only a small part of the curricular support system. The implications of their relationship with other curricular resources are elaborated in the discussion of a digital textbook and a smart class in section 3.2

Case 2: Development of Textbooks

The curriculum takes note of the particular psychological and development needs of children at a particular stage of schooling and suggests syllabi suited to those needs. The syllabi then selects appropriate topics and information and suggests suitable learning experiences, which can help develop relevant abilities. The textbook writers are expected to articulate the topics, keeping in view the conceptual relationships within the topics, the overall objectives of the subject and the present level of children at that stage (both previous learning and psychological readiness).

The writers take recourse to text, graphics, illustrations or photographs, activities, in-text and end of text questions and exercises, and weave the chapter in a language that the student at that stage can process.

The effectiveness of the textbook is not only a function of its own characteristics, but also that of students, teachers, the teaching-learning environment and the overall expectations set by the school. Also, the writers have to make assumptions about the students. Can each student at this stage read and comprehend the text? Can teachers relate the visuals, exercises, activities to the text and help students acquire a conceptual clarity? What if students are visually challenged? Perhaps technology can enable text to be rendered into sounds. But what about the visuals? Textbooks are often translated into different languages. Do the translations remain faithful to the content as well as spirit of the original?

The technological support – a textbook in this case, is a part of a complex sub-system of transaction of the curriculum. Its effectiveness depends on a variety of factors. These factors are also likely to be different in different locations and contexts.

The two cases presented above highlight the complexity of the sub-systems. The complex interactions between the various people, devices and processes underscore the challenge of designing appropriate technological supports. The intent is to suggest the *need for an end-to-end solution, based on a comprehensive identification of the factors influencing its operation*. The challenges presented above are equally relevant even in the case of administration and management. Appropriate technology and an intelligent design of the support system can enhance its effectiveness.

3.2 Potential of Educational Technology

> "*The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency.*"
>
> -- Bill Gates, The Road Ahead, 1995

Information and Communication Technologies have always held a great appeal to educators. Despite the limited purposes devices like an overhead projector played, many enthusiastically embraced it, stacking up reams of transparencies and spending enormous time and effort. Modern versions, particularly a slide presentation software, routed through a personal computer and a multimedia projector have indeed become standard fare in public speaking.

Over the years, a wide variety of hardware and software options have emerged, some even specifically aimed at supporting teaching-learning processes. The emergence of internet and the web, and a variety of networking and communication applications have expanded the use of ICT manifold. The popular appeal of the audio-visual capabilities of the screen, the shrinking of the size and cost of user devices, and the advent of mobile technologies have catalysed a runaway interest in technology.

Policy makers and technology researchers appear to think that modern ICT have the potential to transform education. Indeed ICT applications in the industry and higher education spheres appear to vindicate such a belief. Online education, networking and resource sharing, large and complex information systems, intelligent data handling catalysing decision making have established themselves in various spheres, clearly demonstrating increased productivity and efficiency, leading to significant cost savings.

The aspiration therefore is to replicate this transformation in the education system.

As described in section 2.1 above, a variety of initiatives have been taken in the state and elsewhere and learnings accumulated. Investments on infrastructure have also been made. Although this is far from ensuring universal access to a reliable technology interface, a comprehensive plan to integrate ICT into mainstream practices of education appears feasible.

But in the context of the classroom and teaching-learning, despite the almost ubiquitous reach of these devices at a personal level, surveys and research across the globe has not shown a significant penetration of these devices. A typical teacher does not appear to be convinced that the use of technology constitutes a significant value addition.

The pandemic inflicted disruption of schools provided an opportunity to consider ICT in a new light. The forced separation of teachers and students prompted the use of online learning. Predominantly, teachers replicated their classroom teaching techniques through the online medium. The wider range of possibilities was rarely explored. The web is still a very remote resource for teaching-learning.

The analysis presented above suggests the need for an organic link between particular technologies and educational practices. They also point to the need for a comprehensive plan which encompasses all aspects of the educational process, so as to maximise the utilisation of the infrastructure and realise the most benefits. It must be noted that the IT infrastructure would perhaps be among the most expensive investments and in the absence of a thorough utilisation plan is likely to yield the least returns. Technology options are also likely to be complex and intimidating to the neo-initiate, which can prompt very superficial and trivial engagement with the educational possibilities. Researchers in the field have identified these crucial elements for successful use of technology in education:

- Technology should be integrated into the curricular and instructional framework;
- Technology is best used as one of the components in a broad-based reform effort;
- Teachers training in the use of technology is essential, but changes to their core beliefs about teaching and learning are even more critical;
- Ready access to a wide variety of choices of technological resources – hardware, software and technology enabled content, along with a critical ability to choose from them;
- A long term plan and a support system to handhold the teachers and students, particularly with respect to the upkeep of the technology ecosystem[10].

10 Based on: *The Learning Return On Our Educational Technology Investment – A Review of Findings from Research; Improving education through research, development, and service;* Cathy Ringstaff and Loretta Kelley; 2002

3.3 What purposes can technologies serve?

Technology will not transform education; but a transformed education can benefit immensely from technology.

Depending on the vantage position a person occupies, from where to appreciate the issues with education, different technologies are suggested. Close encounters with technology solutions are of course available in the IT and related industries, not only in manufacturing, but also in warehousing, marketing, logistics, finance, human resource development, etc. The media applications, which have acquired a great amount of sophistication, the ready access to very powerful consumer electronics, particularly cameras and audio-visual devices have all added to the popular appeal of modern information and communication technologies.

In developed societies, particularly where affordance is not a criteria, explorations of technologies which may have an import on the educational process have been frequent and well documented. In recent times, the wish list of technologies have included:

- transformation of the learning environment – e-learning, coding, video assisted learning, augmented reality, gamification, use of mobile devices and social media;
- support to the teacher and teaching-learning – improved collaboration, improved student-teacher connect, improved parent-teacher communication, better access to open educational resources, devices to support various aspects of teaching-learning;
- larger system-wide supports – big data analytics, learning analytics, artificial intelligence, curricular support including for STEM and STEAM.

Each of the above possibilities have been tried out across various educational contexts, with different age groups of students and have been widely reported. Each of these devices, products or services have a niche capability which makes it amenable to an educational use. Some of them have even established themselves as technologies of choice, e-learning for instance.

The complexity of the arrangements, the particular devices, the limited markets and longevity of the technology, have implications for cost and reliability of the solution. They consequently have inhibited their consideration in a public funded education system. In fact, the technology industry has positioned many, if not most such technologies as consumer applications and devices, hoping to minimise investments, at the cost of a longer life and reach the end consumer directly.

It must be recognised that technologies have rarely originated as a response to schooling needs. But taking a cue from its various applications across businesses and industries, a wish list of uses is proposed. This includes: the overall administration and management ranging from the individual school to the state education system level; the capacities of teachers and other personnel at all levels; and the teaching-learning processes.

Broadly, in an order of priority, technology support is sought to serve the following purposes:

- Data and information management system
- Continuous professional development system
- Curricular support system

The reasoning behind such an ordering is that peripheral tasks intervene with the time and space available for performing the core tasks. It is common knowledge that teachers and schools spend a lot of their time and resources on record keeping and data compilation to serve administrative needs. Automation can relieve the system from many of these burdens. Systematic, timely, reliable data can also aid *informed decision making*. And in a widely distributed system like the State's education system, the data that can flow on such a pipeline can be immensely helpful in improving productivity and efficiencies. In the absence of automation and centralised storage, not only does the data become unreliable, but the redundant effort at creating, sharing and maintaining the data costs a completely avoidable investment of time and effort. Data handling and analyses is among the best proven use cases of information and communication technology.

The second in the wish list of technology applications is a continuous professional development system. Updating skills and know-how regularly is a significant contributor to efficiency. Online course platforms have proven themselves to be very successful in scaling up to very large numbers earning itself the name MOOC (massively open online courses). With an increased emphasis on viewing K-12 as an integrated whole, the potential of a technology driven professional development system is immense. A platform which facilitates the delivery of courses can be simultaneously used for organising training interventions across all levels of the system, including teachers, administrators and other functionaries in the system, resulting in massive time and cost savings. Tracking the completion of training and refreshers of different stakeholders aids planning and management. Creating, hosting and delivering a growing library of courses brings together a variety of experts and resources, enhancing the intellectual capital of the education system (training benefits both, the trainer and the trainee) and its capacity to keep its functionaries up-to-date and informed.

The last, but still critical technology application suggested is a curricular support system. However much, the appeal is from an outsider's perspective, the use of audio-visual or other technology support in day-to-day teaching learning has found favour with only teachers of some subjects, at some levels, some of the time. This apparent mismatch between the apparent potential of the technology support and the teacher's impressions about its utility stems from a variety of reasons. On the one hand the textbook, which remains the primary arbiter of the curriculum in the class is designed for a situation which does not require any technology support. Even otherwise, not all topics require technology support. Where they do, the learning experience is best served by a variety of software applications, the use of which becomes complex.

Teaching involves instruction, engaging students in a variety of activities, challenging their learning, practice, student exploration, independent study and assessment of learning. Each of these require to be supported differently, with or without recourse to technology. The preparedness of the system – all functionaries, all processes, all infrastructure – would be essential to ensure appropriate use of technology and yield the maximum benefits.

Designing a curricular support system would be a complex system-wide activity which requires a complete re-imagination of the system.

Details of each of these technology applications are presented below and strategies for planning and implementing them described in section 4.

A Data and information pipeline for informed decision making at all levels

Databases and information retrieval across the school system has already been established and some use of these data for policy, planning and budgeting are being made. Record keeping and data collection for a variety of purposes is an integral part of the activities of a school. These data are compiled and analysed at different levels. Some of these have been converted to electronic forms and some are available online too.

An integrated data pipeline, which brings together a wide variety of data and information existing in the system or being routinely generated is proposed. Such a system holds the potential of normalising the data and simultaneously supporting a variety of administrative and academic needs. They can also be accessed by different functionaries at different levels enhancing their capability to make informed decisions. Appropriate use of technology can drastically reduce the investment of time and effort across the system.

Examples of such data sets which have the potential of serving a large number of users at all levels include UDISE, National and State Achievement Surveys, the Human Resources Management Systems and the Student Achievement Tracking Systems. Presently they serve a limited purpose of communication of information to the authorities concerned. For instance, UDISE data of individual schools or clusters of schools in a given geographical area can be subjected to a variety of analyses to support a range of planning activities, within a school and at other levels.

Presently, results of Board Examinations are made available to schools in an electronic form. Rarely is this subjected to analyses, which can suggest course corrections within the school. Of course, the students whose data is analysed have passed out. But the analyses can support systemic changes. Adopting similar analyses of data at across all levels can strengthen many processes in a school. It is in this spirit that the aspirations of the NEP-2020 to transform assessment, and refocus it on student development should be viewed.

The NEP hopes that the transformation will help the teachers, students and the entire schooling system; continuously revise teaching-learning processes to optimize learning and development for all students at all levels. Towards this aim, it proposes to transform the progress card into a holistic, 360-degree, multidimensional report that reflects in great detail the progress as well as the uniqueness of each learner in the cognitive, affective, and psychomotor domains. It believes that this holistic progress card will form an important link between home and school facilitating the active involvement of parents; and providing teachers and parents with valuable information on how to support each student in and out of the classroom (NEP 2020, sections 4.34 – 4.42). These proposals require a robust data pipeline, necessary software applications and know how to be established.

Once established, such a pipeline can support many newer data sets and newer applications in educational planning and administration. The design of such a system will need a comprehensive data policy, a plan, which addresses system needs, identification of stakeholders, provision of appropriate training not only in technology, but also in the academic aspects of data and its utilisation. The proposed professional development platform can be utilised to host these training interventions too.

Continuous professional support to schools, teachers and other system functionaries

Teachers, particularly those in smaller towns and villages run the risk of professional isolation. Training programmes are a regular feature for the Department of Education, but does not reach all teachers, frequently enough to handhold them throughout their career. Other functionaries of the school system, both administrative and academic can also benefit from professional support. Teachers and staff from the large private school system within the state also remain outside the net of training interventions.

With the proposed set of technology applications, a wide variety of specialised training and upgradation will be required for all functionaries. Technology can play a significant role in providing the much needed ongoing support. As an easily accessible and cost-effective medium, online course platforms, online interactive forums and digital libraries can be leveraged to address a variety of needs of teachers and school administrators. Subject teacher forums have been tried out in the state and have demonstrated their utility and appeal. The initiative demonstrated by teachers in upgrading themselves can be leveraged, and the technology supported peer group can grow into effective *Communities of Practices*, which can be of great value.

Research across the globe suggests that in-service professional development is effective when it is contextual, based on teachers' practice and learned through collaborative and critical engagement with other practitioners, teacher educators, domain experts, and other stakeholders. Participation essentially includes sharing resources, practices, and issues, reflecting on teachers own practice, discussing and commenting on each other's work, connecting evidence from research and theory to their practice, essentially activities that make the teachers practice explicit within the community so that they can share their experiences and engage in critical discussions and learn from each other, building their pedagogical and subject domain knowledge[11]. The networking and communication possibilities of technology can eminently support such communities.

The availability of courses on demand can also support the mandating of courses for various functionaries and a suitable credit system established to ensure regular and timely completion of courses. Adequate attention to the quality of activities and processes across the system can be facilitated.

The establishment of a comprehensive online course platform on the lines of a virtual university is proposed. Such a portal can simultaneously host a variety of interventions, including pre-service and in-service interventions. The initiative will need a strong policy framework guiding the planning and execution of activities. It will also require a variety of course managers, course creators[12], graphics and interface designers and other technical support personnel, who can be drawn from the existing system – faculty from the colleges in the State, art and technical teachers from the schools, etc.

Once established, the online course platform can service a wider range of courses, hitherto not considered. Consequently, a search for expertise beyond the Education department may also have to be considered. Mechanisms to encourage and facilitate individuals and organisations with

11 Based on https://clixguidebook.tiss.edu/books/clix-guidebook/page/community-of-practice-f71, accessed 31 December 2021

12 A course creator should best be defined as a learning experience designer. Giving this broader range to the role itself, mandates the designer to ensure the experience is scaffolded, staggered, inclusive and equitable. It also enjoins the best use of the technological capabilities of the medium.

specialised domain and technical know how would expand the range of the professional development. Evaluation of course quality, analysis of data about course offerings and course completion and research on the coverage and reach will enable the strengthening of the initiative.

Development of an end-to-end curricular support system

As discussed earlier, technology has had its best chance to integrate into teaching-learning, when the teachers have seen a need to and embrace a transformation of their methods. Typical educational technology products have addressed parts of the canvas, projected teaching aids or automation of assessment systems, for example. It is necessary to view the teacher's practice holistically and support each of the component practices through appropriate technology. The purpose is to alleviate the teachers' pain points, improve her transactions, and help her see value in adopting technology.

Technology-rich classrooms are best suited to situations where students are more engaged and more active as learners, and there is a greater emphasis on inquiry rather than drill and practice (Sandholtz et al., 1997[13]; Bozeman & Baumbach, 1995[14]). Technology also encourages student collaboration, project-based learning, and higher-order thinking (Penuel et al., 2000[15]). Technology cannot bring about these changes on its own, but can only support such aspirations of the teacher.

Reimagining technology support for education helps address the following activities and processes:

- Lesson Preparation
  Transform static lesson plans in to interactive, personalized plans; along side, technology reduces teacher effort in creating these plans.

- Lesson Delivery
  Transform teaching from a *sage on the stage* to a *guide by the side, allowing teachers to become coaches* who provide personalized instruction

- Homework
  Transform it from a task-based one to an insight-led activity; alongside reducing teachers' time and effort in creating, assigning and ensuring compliance for homework, apart from engaging students in more meaningful learning.

- Assessments
  Transforming the environment from one inducing *exam fever* to an engaging, automated process, reducing the effort in creating the assessments.

- Self-Learning
  Transforming learning at grade-level in to learning at one's own pace; enabling a higher degree of personalization to individual student's learning needs, and broadening the scope of learning itself.

13 Sandholtz, J. H., Ringstaff, C., & Dwyer, C. D. (Eds.) Teaching with technology. New York: Teachers College Press, (1997).

14 William C. Bozeman and Donna T. Baumbach, Educational Technology: Best Practices From America's Schools, Eye on Education, Inc., Princeton Junction, NJ, (1995).

15 William R. Penuel, Barbara Means and Michael Simkins, The Multimedia Challenge, Educational Leadership, Vol. 58(2), ASCD, (2000)

- Doubt-Resolution
  Transform learning from being teacher dependent to resolving doubts on demand; technology enables students to become increasingly independent in the doubt resolution process.

- Teacher Professional Development
  Transforming the process into an incentive, technology enables scalability and flexibility, providing teachers more choices as well as an ownership of their own growth.

- Parent-Teacher communication and Parental Participation
  Transform the process from being restricted to receiving information at parent-teacher meetings to building cohesive parent-teacher communities; technology enables increased depth and quality of engagement of parents in their children's learning[16].

Much of the blame for the failure to reap the benefits of technology in supporting curricular transactions can be attributed to a failure to treat the curricular support system as a comprehensive whole with a complex set of interconnected parts. So, while teachers have demonstrated the use of audio-visual and other projected aids to support their teaching-learning; collections of digital supports have been hosted online; textbooks have been digitised and recently embedded with links to online resources, these continue to remain sporadic and separate activities, failing to transform teaching-learning processes and emerge as a meaningful addition to the classroom.

A comprehensive system which synergises the effort and brings together a variety of resources to reliably support the teaching-learning process is proposed.

The curricular chain includes syllabi, text and non-text reference material, textbooks[17], workbooks and teacher guides, teaching resources, worksheets and activity sheets, demonstrations, tutorials and other audio-visual support, question banks, assessment tools and exemplar teacher plans. The organic linkages between these varied resources requires that the *curriculum-syllabi-teaching-learning* linkage forms the backbone of the digital repository hosting this collection.

Teaching-learning can benefit from a range of resources including virtual laboratories, question banks supported by evaluation tools, and course delivery platforms, to name a few. Restricting resources to audio-visual media degenerates teaching-learning to *show and tell* affecting the realisation of higher order cognitive skills. Independent access to these resources for students and guidance and mediation by teachers can also help customise the offering to students, who may be ahead or behind their other fellow learners.

The development of each of these resources in itself is an involved task, with specialised know-how. It will further require the services of specialised curators trained in managing digital repositories. The establishment of a comprehensive digital repository serving the needs of all students across the school and teacher education system would require a dedicated and trained team supported by a comprehensive policy framework, guidelines and appropriate technology support.

16 Based on: https://www.centralsquarefoundation.org/reimagining-education-through-technology/ accessed on 31Dec2021

17 The textbook itself will require a complete overhaul and will now be one of the components of the curricular chain with integral links with other components. The reimagined textbook is described in the section "The idea of a digital textbook"

Encouraging contributions from all and evolving a robust mechanism to create, review, validate and curate contributions will enable the rapid growth of the repository. The involvement of teachers across all stages of schooling and across all domains, not just from science, mathematics, or social sciences, but also arts, sports and languages will help establish a sense of ownership for the repository. The repository will have to be constantly updated and managed. A distributed online forum of teachers and other specialists can be established and mandated with the task.

The idea of a 'Smart' Classroom

In the evolution of projection devices, multimedia projectors were interfaced with interactive white boards, which allowed the teacher to perform a variety of modifications to the displayed resource; the novelty of the interactions has prompted this device to be labelled as a smart board and a class containing such a device a smart class. While recognising the need for a smart classroom, there is a need to go beyond the proposition of a technological gadget as the definition of the smart class.

A truly smart classroom must consist of teachers who support smart learning, use curricular resources smartly and endeavour to become smart themselves.

Such a proposition may not even require a smart technological device. Understanding the needs of a learner, aligning classroom and teaching-learning processes to these needs and making smart choices of curricular resources will lead to efficient and productive processes. Ready access to resources which extend learning beyond the textbook, challenge students, facilitate critical thinking and problem-solving will transform the methods of teaching-learning and assessment.

Technologies can indeed play an important role in supporting schooling and must be leveraged to develop smart students and smart teachers.

The idea of a 'Digital Textbook'

Despite a bumpy ride, digital copies of textbooks have become mainstay. But, they are limited to electronic images of the printed textbook, hosted on the internet. While they eminently serve the purpose of ready access, they are still very far from evolving into a useful support for transforming teaching-learning methods.

One essential utility of a digital textbook is making it accessible to the visually challenged. Making text *accessible* requires it to be suitable for screen reader software to read from. Limitations of technology for processing text in Indian languages, limitations of the production processes (at the publishing stage as well as the digitisation stage) resulting in image versions of text, inadequate understanding of how to make non-text elements (graphs, diagrams, maps, pictures) accessible, are some of the issues which make present digital versions of textbooks *inaccessible*. A book making process designed primarily to produce an accessible electronic textbook is distinct from the desktop publishing process used for print versions.

The costs involved in printing and distribution of textbooks have prompted condensing of information, effectively increasing the comprehension burden to the student. Having to restrict itself to the common minimum content of textbooks, examinations further stifle learning. It is a rare creative teacher who is able to take the initiative of overcoming the limitations of the textbook and expand student horizons.

Ideally a digital textbook should seamlessly link to a digital library; in fact, it should be one of the components of the digital library. It should expand various teaching-learning activities, provide access to a variety of additional resources and benefit from the multimedia fare that technology can enable. At the secondary and post-secondary stages, they should also link to relevant data and information sources, prompting higher order thinking. A comprehensive digital library and a complete ecosystem of resources will metamorphose the very idea of a digital textbook and its transaction in the classroom. This will also require a better integration of teaching-learning, library services, print and other media production activities. In effect a digital textbook is not merely a digitised textbook, but an integral part of the curricular support system.

Minimalistic infrastructure and optimising utilisation

Technology roll out has been impeded by infrastructural constraints. It must be recognised that establishment, management and upkeep of IT infrastructure is among the most expensive investments for the education system. Not only does it demand a high capital investment, but also recurring expenses, including many hidden ones. The technology is also management intensive and prone to obsolescence.

Historically, our explorations of ICT began with computer literacy and the desktop computer was its flagship avatar. Conceiving of computer laboratories in a school is still considered the most common way of organising the IT infrastructure. Technologically, however this conception has been superseded. Not only are hand held devices like the tablets or the smartphones more versatile and pack in more computing power, but connected to the internet they can serve a much wider array of applications, far more conveniently. The affordability and easy access to such devices have indeed spearheaded an explosion of ICT use.

Reimagining the infrastructure needs in education may be necessary to optimise the investments as well as their use. Consider for instance the use of a projection system in the classroom. Typically this calls for a laptop or desktop computer, connected to a multimedia projector and a projection screen or an interactive white board. To facilitate the content, it requires packaged resources (video, slides,...) or software applications. This entire arrangement is premised on the argument that the core purpose of student learning is best achieved by ‘a teacher delivering instruction to the whole class’.

If learning is visualised differently, the role of the teacher itself is transformed and the need for a complex arrangement of technology rendered unnecessary. Learning indeed can be facilitated in many different ways and the objective achieved with better efficiency, for instance, a recorded lesson shared offline with students and a forum facilitating discussion or to redress doubts.

ICT literacy and learning coding and computing will still remain important components of the school curriculum. A large array of computers equipped with relevant software applications and connectivity will still serve as a convenient way of servicing this need, but the larger objective of supporting the educational process with ICT applications can be met with a much leaner infrastructure.

Storage in the cloud, web-enabled software (including SaaS), and mobile access has made it possible to conceive of a diminishing footprint of infrastructure, as well as distributed access to content. Software applications are an important component of the expense. Online availability of software and use of free and open source software (FOSS) applications will help reduce the total costs, apart from discouraging the unethical practice of software piracy. Many of the routine and some specialised computing applications can be conducted online, without a need for a local device with installed software. Smartphones are increasingly more capable of performing a wide range of tasks hitherto available only on computers. In fact, they can do much more, and suggest the possibility of re-designing technological access with a minimalist design, leading to savings as well as better efficiencies.

Most of the initiatives proposed here may be adequately addressed by a suitably designed centralised infrastructure accessible by all end-users remotely. The emphasis should be on the development and deployment of the resource centrally and facilitating its use locally. A reliable internet connectivity with adequate bandwidth, with a multitude of smart devices – laptops, tablets or smartphones will serve many more technology based activities than a full-fledged networked lab of desktop computers and servers. They also require far less maintenance and most importantly are not affected by an unreliable supply of electricity. The liberation of the software application and the content from the vagaries of individual devices also significantly increases *up time* and reliability.

4.0 The Way Forward

The aim of this section is to propose a prospective plan for Karnataka's school and teacher education *to suitably transform itself to benefit from the varied applications of Educational Technology*. As highlighted in the foregoing sections, technology can support educational processes, alleviating the user from the drudgery and burden of tasks, embellishing the presentation and speeding up the delivery. It does not have the potential to transform the intent of the process in any way.

A well thought out process is likely to benefit from technology support and become better. At the same time, a poor process runs the danger of magnifying its limitations and become worse.

The preparation for technology infusion therefore begins with a consideration of the educational system. The initial conditions to be fulfilled before introduction of a technology include:

- Identification of the various people, arrangements and processes;
- identification of the linkages between these;
- a consideration of the purpose of the technology intervention desired;
- the relevance and potential of the chosen technology to affect the desired change;
- associated modifications required in order to accommodate the change;
- readiness of the system in terms of motivation and training;
- readiness in terms of technology and its operations; and
- the establishment of a support system to maintain the technology ecosystem and handhold the users.

The establishment of the technology component may be a one time activity (installation of infrastructure, for instance) or an ongoing activity involving many people over an extended time (developing curricular resources, for instance); require arrangements distributed over many

locations or over an extended time (data collection and analysis, for instance); or require a complex set of technologies coming together.

In effect, infusion of technology is a complex process. The path from conceptualising to actual rollout can be very involved and requires a sustained effort. In the light of the three major paths suggested in this position paper, viz.,

- Data and information management system
- Continuous professional development system
- Curricular support system

this section attempts to suggest appropriate strategies for their planning and implementation. Given the complexity of the tasks, they are bound to be extended over a large period of time, need to be broken into convenient smaller tasks and be incrementally grown.

The following steps are proposed to guide the planning process:

- Initiate a comprehensive visioning exercise

The visioning exercise aims to develop an overarching set of objectives for the transformation. For instance, that a range of appropriate curricular resources will be developed to cater to students and teachers at all levels. The details of specific target groups, languages, nature of the resource, etc. will be taken up subsequently.

A clearly articulated objective will allow identifying existing initiatives, resources and persons and suggest ways of synergising them. For instance, the State Achievement Survey data may only require minor modifications to be made available for the newer purposes envisaged.

It is essential to draw up a feasible, but clear timeline, factoring the strengths of the system, particularly budgetary support.

- Draw up a strategic plan to deploy persons, money and technology

This is essentially a mapping exercise at this stage. The development of curricular resources may require persons with specific skill sets. This identification will in turn suggest availability of persons within or outside the system. For instance, suitable arrangements to involve college level domain experts, re-training to involve art teachers from within the system, or budgetary provisions to involve outside resources.

The focus of investments on technology is on developing the backbone or centralised infrastructure, cloud space or web servers for instance. An appropriate timeline will facilitate the rollout of the plan. The deployment of a ‘system manager’ to lead the overall plan will facilitate this activity.

- Establishing the core infrastructure

The various ongoing initiatives in the state has existing arrangements and access to infrastructure. This step involves synergising these, drawing them into a connected whole, facilitating intercommunication between the various parts. For instance, data is likely to exist in separate

databases presently. They may also be using different software applications and interfaces, requiring modifications to serve the newer purposes. Upgradations may also be required to make them mobile friendly or host them on the cloud.

While bringing together a variety of technology components, it is essential to ensure that they communicate with each other. This has particular reference to data and file formats, fonts, etc. The objective will be to arrive at a device and platform agnostic interface, which will allow all user devices to function on them, removing the need for dedicated devices at the user end. The objective of a minimalist infrastructure expects any device – smartphones, laptops, or older desktops to work seamlessly on this. Not only will this be economical, but also facilitate scaling in a shorter time frame.

- Identify initial tasks and mandates for the deployed persons

A system manager at an appropriate level with the overall mandate to rollout and subsequently manage the system is proposed for each of the three paths suggested. This system manager takes charge of the subsequent steps in consultation with domain and technical experts appropriate to the task. A person dedicated to this task is critical for the effective roll out. A comprehensive rollout plan will identify activities, facilitating the deployment of resources, personnel and technology.

- Design a plan for setting up teams for the tasks

The identification of a clear set of tasks and a rollout plan will enable identification of teams around the tasks. Leveraging the technological possibility, the teams can be distributed over a geography. For instance, existing laboratory or production facilities across different locations can be tasked with appropriate deliverables and targets. Team members may require training and orientation to effectively carry out their tasks.

- Design a plan for ongoing evaluation and research

Ensuring accuracy, validity and relevance of the system will require support from evaluators and researchers. Existing provisions of dissertations at the MEd or PhD levels, for instance can be utilised. Appropriately opening out the system for public participation will also facilitate independent evaluation and feedback.

- Roll out the Plan

As the overall plan can be complex, involving many teams of people, many processes, many technological components, a comprehensive schedule of events, timelines, targets and key process indicators will enable the teams to synergise their efforts and deliver the outcomes. The system manager will have to rigorously chase targets, while ensuring the quality of the products and services offered.

The proposed course platform can be leveraged to organise each of the training and orientation envisaged for the proposed plans.

The proposed planning process restricts itself to the centralised core infrastructure. Arrangements beyond, say at the school or local administration levels are to be assessed separately. The plan is generic and applies equally to all the three paths suggested.

5.0 Recommendations

This position paper has attempted to consolidate the various technology initiatives presently underway or to be undertaken in the future under three broad needs of the education system. The first pertains to administration and management of the overall system as well as its individual components like schools or colleges. The second addresses the training needs of all functionaries at all levels of the system. The third strand aims to develop a comprehensive clearing house of digital and digitised educational resources. These resources can serve all functionaries at all levels of the school system, simultaneously servicing a variety of needs, including teaching-learning.

The recommendations listed below recognise that the implementation of these three broad proposals will remain an ongoing project requiring a wide range of people, tasks and technology. The technology itself is likely to evolve over time, some of the components requiring replacements due to obsolescence. Hence the proposals do not refer to specific technology devices and software applications. A focus on the educational principles and consequent outcomes will allow the selection of the most appropriate devices and applications, ensuring their relevance to the project needs, cost-effectiveness and convenience of the users.

5.1 A minimalist technology infrastructure

- Emphasis on a dependable end to end connectivity

Establish internet connectivity to all stakeholders as the minimum basis for ICT implementation. Initiate a mapping exercise to assess existing connectivity, other options for connectivity, provision of budgetary and other technological support, and facilitating the participation of other public agencies – banks, railways[18], not for profit, volunteer and other charitable initiatives in providing connectivity of an adequate speed and bandwidth.

- Simultaneous support to online and offline, synchronous and asynchronous participation

Despite best efforts, there are likely to remain difficult to service pockets. Other systemic constraints like electricity or weather are likely to render connectivity intermittent. While persisting with efforts to establish connectivity is underway, it is recommended that a backup plan to enable participation is initiated. This involves adapting the ICT tasks to function offline – the interface available as an app for instance storing data locally and pushing it to the online platform when connectivity is available. Further the applications are designed to possess a minimal dependence on synchronous communication.

18 These agencies are likely to have established reliable connectivity for their own purposes and can easily extend support to the school.

- Support to a variety of user devices and *BOYD* schemes

An initiative similar to banking[19] is recommended for automating and enabling the participation of the educational functionaries.

Provision of fixed infrastructure in the schools and offices – desktop computers and other accessories may already exist or be needed for other applications; the range of applications proposed are designed to require very little dependence on large data packets or computing power. It is recommended that the ICT applications are so designed to simultaneously support different devices. A scheme to incentivise personal procurement of devices and facilitation of a *bring your own device* environment is likely to catalyse participation and ownership.

5.2 A comprehensive re-imagination of the educational process

A systematic identification of educational processes and components and integrating them into the ICT plan is essential ensure the success of the ICT implementation. A visioning exercise with a commitment to a time bound implementation is recommended. This can instil the confidence to undertake complex transformations of the kind proposed – all data entry at all levels will be electronic only; or printed textbooks are adaptations of a more comprehensive digital textbook; or all teachers must undertake and complete a professional development of a given duration. It must be noted that in the absence of a comprehensive transformation, the initiative is likely to outsource the running of a constrained system to technology and as has been seen time and again, technology will only aggravate the faults.

5.3 The establishment and roll out of a data and information management system

- Establishing the system, processes and personnel

    1. Identify a system manager at an adequately senior level to lead the team;
    2. Develop a vision, design and process document with the help of experts in the relevant fields;
    3. Identify existing data applications and their uses, evolving a plan to integrate them;
    4. Develop a phased out plan factoring in system needs, preparedness, availability of funds, etc.;

- Establishing the technology

    1. Identify target applications, relevant data sets, interfaces and relevant training needs;
    2. Identify existing data applications and related processes and develop a plan to integrate the[20] datasets and applications;

19 The banking sector today functions and services its online banking applications through a variety of devices which seamlessly work with each other. A desktop computer at a branch, an ATM, a point of sale card reader device, a mobile app, web-based online banking, and the unified payment interface – UPI, function with slightly differing roles, but on the same customer and bank credentials.

20 It is likely that the different data applications presently demand repetitive filling of similar data; in the absence of an integration, it is likely that the requirements of the different databases as well as errors in data input lead to invalid data; a unified interface catering to all applications will streamline processes and avoid such errors.

3. Identify personnel at each stage responsible for data inputs, maintaining the data and the technology platform, and undertake compilation, analysis and publishing results;
4. Establish the centralised technology infrastructure[21] – involves synergising existing infrastructure, designing newer infrastructure and porting all existing applications and data into them;
5. Identify infrastructure needs at user ends and roll out appropriate interfaces, apps and forms[22]
6. Identify security concerns, privacy issues and relevant protocols to ensure compliance at all levels;

- Evolving timelines and targets

1. Identify outcomes, relevant activities and phase them out appropriately;
2. Identify deliverables or targets against each activity;
3. Establish protocols to manage the timelines and targets;

- Identifying key process indicators and evaluating outcomes

1. Identify the key processes involved in each activity, roles and responsibilities of personnel involved;
2. Identify benchmarks of performance, evaluation protocol and tools;
3. Establish a reporting, monitoring and evaluation mechanism;
4. Evaluate the individual processes, technology and outcomes;
5. Facilitate the publishing of results;

5.4 The establishment and roll out of a continuous professional development system

- Establishing the system, processes and personnel

1. Identify a system manager at an adequately senior level to lead the team;
2. Develop a vision, design and process document with the help of experts in the relevant fields;
3. Develop a comprehensive list of trainees across all levels of the system;
4. Develop a comprehensive, growing list of training needs and a mechanism to constantly assess future needs;
5. Develop a mandate[23] for training at different levels and facilitate course delivery;
6. Develop a phased out plan factoring in system needs, preparedness, availability of funds, etc.;

21 As a general prescription, this position paper suggests the use of cloud infrastructure and where feasible, online applications. This minimises the infrastructure maintenance needs, allowing larger attention to the educational application. This principle can be adopted for all the three proposals.

22 Keeping in view the principle of a minimalist infrastructure the user interface should be simultaneously accessible to a variety of devices; a mobile first ‘mobile-first’ approach rather than use of Laptops, desktops, tabs etc. is useful. Such a strategy can be cost effective in reaching the target population.

23 A mandate to each teacher for example to seek, select from, enrol and complete courses each year; prescribing the total duration of course participation per year; and an appropriate facilitation as well as incentivisation.

- Establishing the technology

    1. Design a training design which will inform the features of the technology platform;
    2. Develop an appropriate course platform and deploy it;
    3. Identify personnel – course creators, managers, support personnel for authoring, and facilitate their technology needs;
    4. Design protocols for course creation, review, authoring, hosting and evaluation and a mechanism to appropriately train personnel involved;
    5. Identify existing courses[24] and enable their porting into the course platform;
    6. Establish the centralised technology infrastructure – involves hosting, maintenance and updation of the course platform, design protocols for creating and managing courses and their evaluation;
    7. Identify infrastructure needs at user ends and roll out appropriate interfaces, apps and forms
    8. Identify security concerns, privacy issues and relevant protocols to ensure compliance at all levels;

- Evolving timelines and targets

    1. Identify outcomes in terms of personnel taking the courses, the range of courses available against each target group, relevant activities and phase the roll out appropriately;
    2. Phase out the activities and evolve a suitable timeline as well as targets;
    3. Track course development and deployment, course offering and course completion;
    4. Establish protocols to manage the timeline and targets;

- Identifying key process indicators and evaluating outcomes

    1. Identify the key processes involved in each activity, roles and responsibilities of personnel involved;
    2. Identify benchmarks of performance, evaluation protocol and tools;
    3. Establish a reporting, monitoring and evaluation mechanism;
    4. Evaluate the individual processes, technology and outcomes;
    5. Facilitate the publishing of relevant data and results[25];

5.5 The establishment and roll out of a curricular support system

- Establishing the system, processes and personnel

    1. Identify a system manager at an adequately senior level to lead the team;
    2. Develop a vision, design and process document with the help of experts in the relevant fields;

24 A large number of courses have been organised by the Department of Education for various target groups and for different training needs. Many of these exist in print or partially digital forms. These courses can be adapted – digitised, re-authored or used as an exemplar to design similar courses.

25 The number and range of courses undertaken by a particular target group is useful information for planning future courses as well as implementation of programmes through that target group.

3. Develop a design document describing the range and nature of curricular resources needed at various levels;
4. Develop a plan to identify existing digital or digitisable resources, resource platforms and to integrate them;
5. Develop a phased out plan factoring in system needs, preparedness, availability of funds, etc.;

- Establishing the technology

1. Design a curricular support model, which will inform the features of the technology platform and the facilities required for managing the resources;
2. Develop an appropriate repository platform and deploy it;
3. Identify personnel – resource creators, curators[26], reviewers and support personnel for designing and developing the resource[27], and facilitate their technology needs;
4. Design protocols for resource creation, review, authoring, hosting and evaluation and a mechanism to appropriately train personnel involved;
5. Identify existing resources and enable their porting into the repository platform;
6. Establish the centralised technology infrastructure – involves hosting, maintenance and updation of the repository platform, design protocols for creating and managing resources and their evaluation;
7. Identify infrastructure needs at user ends and roll out appropriate interfaces, apps and forms
8. Identify security concerns, privacy issues and relevant protocols to ensure compliance at all levels;

- Evolving timelines and targets

1. Identify outcomes in terms of the range of resources, their relevance and utility for different educational needs and target groups, identify relevant activities and phase the roll out appropriately;
2. Phase out the activities and evolve a suitable timeline as well as targets;
3. Track resource development, deployment and their utilisation;
4. Establish protocols to manage the timeline and targets;

- Identifying key process indicators and evaluating outcomes

1. Identify the key processes involved in each activity, roles and responsibilities of personnel involved;
2. Identify benchmarks of performance, evaluation protocol and tools;
3. Establish a reporting, monitoring and evaluation mechanism;
4. Evaluate the individual processes, technology and outcomes;
5. Facilitate the publishing of relevant data and results;
6. Identify and redress technological challenges if any, particularly at the user ends.

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26 Curation is a unique process, typical of digital repositories. It involves categorising the resources in multiple ways; mapping a set of keywords against each resource and placing the resource in its appropriate location; these activities together enable the discoverability of a resource and its re-use in various other contexts.

27 The resources may exist in a variety of media formats, singly or in combination and will require teams uniquely qualified and equipped to develop them; video recording and editing teams, graphics or animation developers, etc.

5.6 Continuous research, evaluation and public participation

A complex transformation of the kind recommended requires a long term commitment and support from the system. It is hoped the support to NEP 2020 implementation, both at the Central and State Government levels will be able to provide the financial and policy support to the initiative. A number of existing initiatives like UDISE, NAS and SAS, NISHTA, DIKSHA are projected to be expanded and institutionalised by the Government. Schemes like VidyaDan are also proposed to encourage the participation of experts. Karnataka has the good fortune of having attracted the growth of various IT industries, support from whom can be readily sought. The proposed visioning exercise requires a high level of technical expertise, leveraging existing ICT possibilities and synergising the efforts. An open mechanism which facilitates their participation is recommended.

In particular, a state of the art ICT initiative requires an unwavering attention to the finest detail as well as a high level of quality. Research and evaluation can emerge as the most significant mechanism to locate and improve the products and services. Available expertise from within and outside the system need facilitation and incentivising. Existing mechanisms of seeking ratings, comments and reviews must be comprehensively scaled up to cover all aspects of the implementations. These should be supported with evaluation camps, contests and competitions, celebrations and setting of higher benchmarks.

Appendices:

Appendix 1: A historical timeline of initiatives undertaken in Karnataka for ET/ICT in education

Dates	Programs/Initiatives
1986	PMOST and Operation Blackboard; print and non-print resources distributed; included radio-cum-cassette players, audio content, VHS video content to schools
1990s	Separate ET wing in all 34 DIETs with 1 head and 3-4 teachers; e-content created and training through e-content experimented
1990s	Computer labs in schools, initially through NGOs and later from the Department; Pre-loaded content – movies, videos, motivational content etc.
Late 90s	CLASS Project –Computer literacy program
2000	Mahiti Sindhu by State; Computers to 1000 schools
2004 to now	Samveda Banuli –Television and radio broadcast through EDUSAT; grade specific pre-recorded and live content
2004, 2010	Establishment of computer laboratories and ICT training of teachers and students; Ed-tech for both education and administration
2016-17	Computer Assisted Learning Programme to Technology Assisted Learning Programmes – Phases 1, 2, 3; Self-running content for both students and teachers Laptop + preloaded content; some initiatives for content development
Ongoing	Teacher training - Nishtha, Guruchetana
2010	Choice-based training – Online; Teachers choose the modules for their training
2016-18	Besige Sambhrama and Prerana statewide - data collection on apps; Access to real-time data; Ease of reporting
2016-20	Certificate courses to Department Officials on MOOC platform
2016-20	Computer Literacy program to all the Government employees
2019-20	Energised text books with QR codes; link takes to e-content in Diksha and video lessons; Inclusion of tech enabled learning in UDL (Universal Design for Learning); Inclusive education – to provide hybrid text books common to all students including specially abled and integrating online content
2018-20	Populating Diksha, a national repository – content for Teachers and Students
Ongoing	Subject Teacher forums; huge pool of Open Educational Resources Exchange between teachers
Ongoing	National Skills Qualification Framework -Tech education; option to choose an ICT subject instead of third language in 9th and 10th
Ongoing	SATS -Student achievement tracking online; Digitalised student information and Analysis
Ongoing	E-procurement by the department; Online transactions
Ongoing	Digitalisation of information, e-office initiatives
Ongoing	Textbook dept. Content stored in soft-versions (CDs), enabling version control and upgradation

Ongoing	Exam application, scholarship application, TC, Marks card, Re-evaluation, results are all online
Ongoing	UDISE; Digitalised student, teacher and school information
Ongoing	E-governance; Online communication and administration for ease
2021	E-pub - audio books and audio content; Students, particularly visually challenged
2021	Pilot of MOOC by DSERT with ILP in north Karnataka for Teachers
2020-21	Extensive use of Whatsapp and Drive by teachers and students to exchange and upload assignments, worksheets, photos of events, photos of student's work corrected – use of technology during pandemic
2019-20	E-edu management program by Sikshana Foundation to the CRPs and BRPs; Training helped officials use the basic ICT skills they already have to collect, process and analyse data.

References:

IT and Digital initiatives of Karnataka Education Department; http://164.100.133.7:81/bestpractice/talp.pdf

Online learning ICT initiatives by MHRD and UGC: https://www.ugc.ac.in/pdfnews/1573010_On-Line-Learning---ICT-initiatives-of-MHRD-and-UGC.pdf

Various initiatives have been taken to promote digital learning under 'National Mission on Education through Information and Communication Technology' (NMEICT): https://pib.gov.in/Pressreleaseshare.aspx?PRID=1577240

ICT Initiatives – NCERT: https://ictschools.ncert.gov.in/

Karnataka under IT Schools Project: https://ictcurriculum.gov.in/course/index.php?categoryid=98

TALP ; https://dsert.karnataka.gov.in/info-1/Education+Technology+cell+&+State+Institute+of+Science/TALP+-+IT+Schools+in+Karnataka/en

Nishtha1.0 elementary level analytics https://n20.ncert.org.in/analytics1.php