Chapter 19

Technology in Education

Objective: Appropriate integration of technology into all levels of education - to support teacher preparation and development; improve teaching, learning and evaluation processes; enhance educational access to disadvantaged groups; and streamline educational planning, administration and management.

India is a global leader in ICT and in other cutting-edge domains such as space. The Digital India Campaign is helping to transform the entire nation into a digitally empowered society. Quality education will play a critical role in this transformation, and technology itself will play an important role in the improvement of educational processes and outcomes. Thus, the relationship between technology and education at all levels is bidirectional.

The use of technology in education can be classified broadly into four categories, three of which are concerned directly with students, teachers and classroom processes. The first and most important area is teacher preparation and their CPD. It is essential for teachers to receive adequate training in how to leverage technology to improve educational outcomes. Teacher preparation may itself leverage technology (e.g. through the use of online courses), but the quality of training must be of the highest quality. A second important area where technology can be impactful is in the classroom processes of teaching, learning and evaluation. Technology-based tools must be created in response to challenges in these areas, in a continuous process. The tools must be carefully evaluated to ensure that they address the challenges without creating additional new ones. The third area is the use of technology to improve access to education for disadvantaged groups, including differently-abled students, girls and women, and students living in remote areas. The fourth area is the planning, administration and management of the entire education system.

Since technological change is rapid, it is essential to acknowledge key technology trends in order to identify ways in which education can leverage not just current technologies but emerging technologies as well. The first technology trend of relevance is the increasing access to electricity, partly due to ongoing government initiatives to expand electricity networks, and partly due to falling costs of locally generated power such as solar energy. In view of this trend, this Policy advocates focused electrification of all educational institutions at the earliest, since access to electricity is a basic requirement for all technology-based interventions. The second technology trend is the falling cost of computation, data storage, and data connectivity. This trend is largely driven by market forces, and it enhances the feasability of sophisticated educational applications that can gather, process and share data (as opposed to simpler, stand-alone applications). This immediately links to the third technology trend, namely the increasing importance of data. Not only is it becoming easier to gather and process data, but tools to perform sophisticated data analysis are becoming easier to use. It is therefore important to ensure that data is secured against misuse and that privacy concerns are carefully addressed. A suitable institution must be empowered to analyse this data and this task has been assigned to the CESD that is to be set up at NIEPA (see P6.1.5). Finally, an important technological trend is the accelerated rate at which disruptive technologies are emerging.

In view of these trends, it is worth highlighting their implications for infrastructure, end-user hardware, software development, deployment and data. The use of technology in education is likely to require considerable investment in basic infrastructure such as electricity, hardware and connectivity. The bulk of schools and colleges in remote and rural areas do not have access to the basics (electricity, hardware and reliable connectivity) and, government must ensure that this situation is remedied at the earliest, if not at the level of each individual school then certainly at the level of school complexes.

With regards to end-user hardware, it is important to draw a distinction between institutional devices such as desktop computers, classroom projectors, WiFi routers, etc. and personal devices (such as smartphones and laptops). Educational institutions must be allowed to purchase and maintain institutional devices to support technology-based educational activities such as blended learning and computer-based laboratories. A key area of concern is the non-availability of local expertise to help use and maintain all the relevant hardware and software at these locations. Funding for hiring trained IT staff, at school complexes for instance, must be provided as needed. However, this effort can be complemented imaginatively by stationing trained local youth, either engineers or those with adequate technical training in hardware and software, at these locations. They must be provided with special, named, fellowships lasting two to three years during which time they can be associated with schools, school complexes and other educational institutions in rural areas to help them with the induction and use of technology. [see P19.4.5]

The success of solutions that require institutional devices has been limited, in part due to non-uniform availability of resources for procuring them and in part due the lack of knowhow available locally for maintaining equipment. For

this reason, the increasing availability of personal devices needs to carefully considered. Today, low-cost personal devices provide data communication, computation and multimedia on a single platform, and students generally learn to operate them quickly and effectively. Hence, personal devices have the potential to support technology-based educational interventions. There is a need to recognise however, that access to such devices is not universal, and that they can also be addictive and distracting, and hence detrimental to learning. A well thought out approach to making use of personal devices in educational institutions is needed.

Several models for the creation of software for education exist, ranging from software platforms such as SWAYAM commissioned by the MHRD for use by the entire country, to applications and software developed and tested by educational institutions such as IIT Bombay that need to be scaled, and software applications created by entrepreneurs that need to be evaluated and inducted if found to be useful. Although several innovative software solutions have been created over the past 2-3 decades and are in use, a mechansim to drive the cycle of:

- Identifying stakeholder (student, teacher, administrator) needs,
- Creating technology-based solutions that address these needs,
- Assessing these solutions in meaningful pilots, and
- Deploying them at scale, with government funding as needed,

is missing in the system. This lacuna can be filled by setting up of special body that can be assigned this task (see P19.1.1).

Both top-down and bottom up approaches to software development and induction need to be supported on a continuous basis. The proliferation of cloud computing technologies makes it relatively easy to scale successful software solutions across all educational institutions, either on a State-by-State basis or at the National level. Examples that illustrate this principle well include software created as part of the National Mission on Education through ICT (NMEICT), such as Virtual laboratories that provide remote-access to laboratories in various disciplines of Science and Engineering, and Spoken Tutorials that help students learn and use open source software by listening to audio commentary in Indian languages. Certain types of educational software can be standardised (at State/National levels), which can leverage scale to reduce development and operational costs per person/institution.

Promotion of the use of open source software in education is another area that requires considerable support, and the existing effort of FOSSEE (Free and Open Source Software in Education) needs to become much more widespread. The challenge with the use of free and open source software of course is the higher level of technical competence that is required at each individual institution, and this challenge must be addressed too (see P19.4.5). In addition, there must be active encouragement for faculty in educational institutions, those who are involved in the development of key

pieces of software in education, to incubate companies so as to ensure that these solutions are evaluated and inducted / actively marketed to educational institutions. In the past, entrepreneurship among faculty, in technology or in other areas, has been actively discouraged. This is changing now but much more encouragement is needed for faculty and student teams to engage in entrepreneurship. Faculty must be rewarded for this in their performance appraisals.

While it is natural that many software initiatives are seeded by the Government of India at premier institutions such as IIT Bombay or Homi Bhabha Centre for Science Education (HBCSE), adequate attention needs to also be paid to the task of making these software solutions available to all educational institutions in the country. This can be done in more than one way and the appropriate choice needs to be made based on considerations of the size of the target group, the urgency and the costs:

- They can be popularised by the developers themselves as is being done now, which is best for niche solutions in technology;
- They can be handed over to institutions such as the Centre for Development of Advanced Computing (CDAC) so that they can maintain them with a 24x7 helpdesk that educational institutions can avail of;
- A new company is incubated by the developer institution to actively popularise the solution and provide support for adoption and maintenance to the educational institutions.

PPP models for these can also be explored, and government can also consider paying for solutions created by the private sector to be deployed at scale. Recipient educational institutions can either receive budgetary allocations to evaluate and adopt specific technologies in the 'PULL' model), or have it made available to them through the State or Central government in the 'PUSH' model. The two options are useful in different contexts and need to be used appropriately, else hardware and software will remain unused as it does today in many institutions.

With regards to data, there are at least three categories to consider. Some data is personal to individuals - teachers and young students. In order to safeguard privacy, the strictest possible privacy regime is necessary to ensure that personal data cannot be shared without the explicit consent of the concerned individuals or their guardians. Some data pertains to groups of individuals (e.g. all students in a particular class, or all teachers in a particular institution), and such data can be shared with appropriate safeguards to ensure privacy. A third category consists of data generated and consumed by educational applications. Such applications increasingly use advances in artificial intelligence to grow in sophistication, and the value of such data is therefore growing. This Policy recognises the need for an evolving set of guidelines related to such data, to ensure that it is not misused.

19.1. Setting up of a new National Educational Technology Forum

Many experiments and pilot studies on the use of technology for improving the quality of education in school as well as higher education have been undertaken all around the country over the last two decades. These need to be reviewed for their outcomes and carefully evaluated for their benefits, risks and effectiveness, as well as their potential to scale, in the different contexts in which they need to be deployed. This is a complex task requiring a wide range of expertise.

> **The National Educational Technology Forum will be a platform for the free exchange of ideas on the use of technology to improve learning, assessment, planning and administration.**

P19.1.1. **The National Educational Technology Forum:** An autonomous body, the National Educational Technology Forum (NETF), will be created to provide a platform for the free exchange of ideas on the use of technology to improve learning, assessment, planning, administration, and so on. The aim of NETF will be to facilitate decision making on the induction, deployment, and use of technology, by providing to the leadership of educational institutions, State and Central governments and other stakeholders the latest knowledge and research as well as the opportunity to consult and share best practices with each other.

P19.1.2. **Role and functioning of the National Educational Technology Forum:** The NETF will have the following roles:

a. Provide independent evidence-based advice to Central and State government agencies on technology-based interventions;

b. Build intellectual and institutional capacities in educational technology;

c. Envision strategic thrust areas in this domain; and

d. Articulate new directions for research and innovation.

To remain relevant in the fast-changing field of educational technology, the NETF will maintain a regular inflow of authentic data from multiple sources including educational technology innovators and practitioners, particularly at the grass-roots level, and will engage with a diverse set of researchers to analyse this data. It will act as a forum for harnessing the distributed energy that democratising technology can unleash, particularly among the youth of the country who continually prove their capacity to innovate and lead, while also bringing a scholarly emphasis to ensure that the overall impact of these efforts is positive.

P19.1.3. **Funding and support to the National Educational Technology Forum:** To ensure deep connectivity with the field of education, NETF may be housed within CIET/ NCERT/ NIEPA or any suitable body determined by the RSA. While NETF will be supported initially with public funding, it should also be able to receive funding from other sources such as memberships, and other neutral technology industry bodies such as NASSCOM among others. The work of NETF will be supported by decentralised institutional structures at the State and District levels, whose specifics may be decided by the RSA, in consultation with the States.

P19.1.4. **Collective assessment and adoption of technology solutions:** To support the development of a vibrant body of knowledge and practice, NETF will organise multiple regional and national conferences, workshops, etc. to solicit inputs from national and international educational technology researchers, entrepreneurs and practitioners. NETF will enable educational technology experts from schools, universities, research institutions and other organisations to evaluate these inputs against current best practices from multiple perspectives, including pedagogical, psychological, social and economic, and distil them into:

a. Necessary interventions, which should complement existing best-practices and be implemented immediately in specific contexts;

b. Promising interventions, which require additional large-scale studies that could, for example, be funded by NRF; and

c. Inappropriate interventions, which ought not be considered.

Such analysis will be regularly and publicly disseminated, and may be used to advise Central and State governmental agencies on all matters related to educational technology, including interventions that may be continued, piloted at scale, or discontinued. NETF may also use this analysis to propose strategic thrust areas and research directions in educational technology for NRF to consider funding.

19.2 Approach to the induction of technology

Global evidence suggests that the effects of technology on classroom processes and educational outcomes, particularly for very young childen, are modest and mixed with multiple sociological and psychological side-effects. However, many other uses of technology, including in teaching, learning and assessment for older children, have tremendous transformative potential. Therefore, a positive yet cautious approach to the induction of technology at scale will be adopted, to ensure that the limited funds available and energies devoted to educational technology are deployed in an optimal manner.

P19.2.1. **Qualified support for educational technology with teachers playing a central role:** All use and integration of technology to improve multiple aspects of education will be supported and adopted, provided these interventions have been rigorously and transparently evaluated in relevant contexts before they are scaled up. Education technology is amongst the most powerful array of tools and methods that a teacher may potentially use in her/his work. Teachers will be completely empowered through adequate training and support to lead the activities and initiatives related to the use of appropriate technologies in classrooms, and for all other uses of technology in educational institutions.

P19.2.2. **Technology use and integration in educational settings:** Technology use and integration will be pursued as an important strategy for improving the overall quality of education. Thus, the focus will not just be on creating and delivering high quality content, but also on using technology to: support translation of content into multiple languages; assist differently-abled learners; improve the quality of pedagogy and learning processes through the use of intelligent tutoring systems and adaptive assessment systems; create new types of interactive and immersive content (e.g. using augmented and virtual reality); strengthen educational planning and management and bring greater transparency and efficiency to the examination system as well as to administrative and governance processes; assist in the management of education such as supporting teacher development programmes; and scale up the ODL system so that it can respond to the growing demand for education from all age groups, across school education, higher education, professional and vocational education, adult education, and lifelong learning.

P19.2.3. **Centres of Excellence in Educational Technology:** Centres of Excellence in Educational Technology will be established at prominent Universities and other institutions to perform research as well as support functions for the uptake of appropriate technology solutions. These Centres of Excellence will be represented at the NETF and they will engage themselves in a two-way interaction with other members of the NETF for sharing of knowledge and knowhow.

P19.2.4. **General guidelines for technology-based interventions:** Three main components will form an integral part of most technology-based interventions: hardware, software and data. In general, the following guidelines will be used. Exceptions to these guidelines, if any, will be carefully and publicly justified.

a. Hardware: Commodity hardware solutions such as cloud-based commercial infrastructure and personal computing devices for end-users will be preferred.

b. Software: Software for educational use will preferably be FOSSEE. Where necessary, the government will pay for professionally developing and maintaining the software, and will acquire the rights to distribute it to learners, teachers and institutions for free-and-unlimited offline usage. Steps will be taken to ensure that this software remains compatible with popular and affordable end-user computing devices.

c. Data: All public data will be owned by the government and will be used for improving educational standards (see Section 19.6). Individuals will retain full ownership of their own data, which may not be used without their explicit permission. In line with the Open Data Initiative, educational data that has been anonymised, as per the best-practice in data security, will be made publicly available on a regular basis for research purposes.

19.3 Teacher preparation and continuous professional development

A very large effort towards the CPD of teachers will be needed if the implementation of this Policy is to succeed. Many online learning experiments do not work very well for first-time student learners who really need a classroom environment that provides oportunities for peer learning, as well as mentoring and guidance from faculty. However, this is not true for existing faculty who are mature enough to be able to make the most of online courses. Most faculty members will require upgradation of their subject knowledge, which can just as well be done through online education.

With regard to school teacher preparation through the four-year integrated B.Ed. programme, the considerations are similar to all undergraduate programmes. Online, open and distance education, can both be used, but extremely judiciously. Teachers will also need to be prepared to use education technology in classrooms.

P19.3.1. **Teacher preparation in the use of educational technology:** To skill teachers at all levels in the use of educational technology, all teacher preparation programmes will include hands-on training in leveraging technology-based resources, including addressing common problems related to connectivity, maintenance of equipment and its safe operation, pedagogical strategies for utilising e-content (including conducting classes effectively in a flipped mode

and leveraging MOOCs), and using appropriate tools to enhance teaching-learning processes (e.g. tools to assist CWSN and tools to help teachers reflect on their pedagogical styles by capturing classroom practices).

Videos in the open educational repository (see P19.5.2) will be used for teacher training discussions in every subject. Appropriate technology-based tools will be developed to assess competencies of teacher trainees, including, but not limited to, competence in the use of educational technology for improving teaching, learning, and evaluation processes.

Initially, a large number of certified master teachers will be trained to provide training to all teacher trainees in a phased manner. Hence, a suitable initiative will be launched and run in a mission mode for 5-6 years by the CIET.

P19.3.2. **Use of educational technology for continuous teacher professional development:** An online training platform - linked to appropriate mechanisms to certify trainees in specific areas - will be developed to empower in-service teachers at all levels of education to stay at the cutting edge of pedagogical techniques.

Since teachers will have increasing access to personal computing devices (e.g. smartphones), all in-service teachers will be provided with sufficient connectivity to access this training platform, explore high quality online educational resources to incorporate into their pedagogy, and participate in online teacher communities where best practices can be shared. The online platform will also allow teachers to share ideas and showcase their pedagogy; teachers with outstanding portfolios will be awarded due recognition, including financial support for participating in national and international training sessions, conferences, workshops, etc., and invitations to present their work at NETF events.

P19.3.3. **Specific technology related policy actions:** The necessary interventions must include customised courses for faculty development programmes on a platform such as SWAYAM. Both for school teachers and for faculty in higher education, SWAYAM can cover the theoretical aspects of learning. At the same time, DIETs and and HRDCs will continue to provide academic support to school teachers and faculty in higher education, respectively. The course contents must be reengineered for the online mode and not be simply recordings of classroom interactions. Similarly, the assessment for certification must be designed in a way that is convenient for teachers, but also rigorous enough to create value.

The development and widespread use of teacher professional learning communities, where teachers can interact with other teachers teaching the same subjects and exchange knowhow, experience, and even educational content is a promising intervention that is already in use in some States with great impact. This must be encouraged and expanded to cover many States and different subjects.

19.4 Improving teaching, learning and evaluation processes

The Internet is a veritable treasure house of text, audio and video that can be used for educational purposes. Availability of an adequate number of access devices (rapidly becoming smart phones or iPads and equivalents) and controlled access (for safety purposes) to the Internet can empower teachers as well as students to make use of these resources and even contribute to creating more. They can engage in many forms of active learning, using the available material to do projects, engage in self as well as group learning methods that can completely transform the delivery of education from the present 'chalk-and-talk' models prevalent in most classrooms in India today.

P19.4.1. **Integrating educational technology into the school curriculum:** To prepare school students for the digital age and bolster efforts in STEAM (Science, Technology, Engineering, Art & Design, and Mathematics) education, the following steps will be taken:

a. From age 6 onwards, computational thinking (the thought processes involved in formulating problems and solutions in ways that computers can effectively execute) will be integrated into the school curriculum. This is a fundamental skill in the digital age, and it can be effectively taught with well-designed paper worksheets.

b. Given the diffusion of devices and their affordability, all students are likely to have access to connected personal computing devices by 2025. The school curriculum will promote digital literacy using these personal devices as well as available digital infrastructure (computer laboratories, tinkering laboratories, makerspaces, etc.).

c. The school curriculum will offer optional subjects focused on programming and other advanced computer-based activities at the late upper primary and secondary stages.

P19.4.2. **Developing educational software:** A rich variety of educational software will be developed and made available for students and teachers at all levels. All such software will be available in all major Indian languages and will be accessible to a wide range of users including CWSN and differently-abled students, and will include:

a. Software to assist learners with disabilities (e.g. text-to-speech software in all major Indian languages for blind/partially sighted students).

b. Intelligent Tutoring Systems to promote numeracy and foundational literacy in all major Indian languages.

c. Educational software in the form of serious games, simulations, and applications using augmented and virtual reality.

d. Software to create personalised learning trajectories for each learner based

on curriculum, with content (readings, videos, interactive worksheets, etc.) arranged in learning ladders.

e. Adaptive assessment tools that provide formative feedback to help learners take remedial steps, such as self-study or learning collaboratively with fellow students.

Software to help teachers create adaptive assessments, formative as well as summative, evaluate the assessments, and provide appropriate feedback to learners. Such assessments will minimise the importance of rote memory, and will instead focus on 21st century skills including critical and creative thinking, communication, and collaboration. Data generated by such tools, that reflects the performance of individual learners and overall institutional performance, will be appropriately recorded in the NRED for subsequent analysis and research (see P6.1.5).

P19.4.3. **Video viewing equipment:** For maximal use of content in the open educational repository, institutions will be supported with inexpensive and portable video viewing equipment (e.g. solar powered video playback and projection devices). Teachers will be encouraged to integrate such videos into teaching-learning processes, along with their own teaching, where ever they add value.

P19.4.4. **Advanced online courses:** Educational institutions will be encouraged to offer course credits to students who complete specified courses (especially advanced electives) online, e.g. via SWAYAM or other such platforms developed in the future. This will include courses on topics such as IT Enabled Services (ITES) and other such areas of vocational education and adult education that can benefit from online courses.

P19.4.5. **Support for appropriate information and communication technology usage:** Most educational institutions have difficulty maintaining and using their hardware and software. This problem can be addressed through the creation of a large number of prestigious 'IT Ambassador' Fellowships for students who have completed their senior secondary courses. They can support school complexes with managing their IT infastructure in a version of rural service that is similar to military service in some countries. Computer hardware and maintenance, as well as training in software installation and maintenance (especially for open-source software) must be taught to these students. As far as possible, local people must be given these Fellowships. This will also help promote entrepreneurship among these Fellows at a later date.

P19.4.6. **Specific technology related policy actions:** These are split into two groups, the necessary interventions and the promising interventions. Some of the necessary interventions in teaching, learning and assessment are the following:

a. **Content repositories in Indian languages for educational content:** along with editorial processes for uploading content, and rating methods that will allow the best content to surface to the top. The content must be made available under the Creative Commons Licensing. The National Repository for Open Educational Resources (NROER) is one such example, but it needs to be supplemented with much more awareness building so that a lot more content comes online and more people find it useful. A suitable financial model to sustain such a repository needs to be selected. The content repository could optionally be integrated with payment systems so that, in time, content creators can be compensated in a small way for contributing content. This will incentivise many teachers to create innovative age appropriate content. The decision to create separate repositories for each State, or hold all content in a single repository, can be made by the NETF based on appropriate financial models.

b. **Machine translation of content uploaded into any content repository:** This should be supplemented with editorial processes to check the quality of translation, so that good quality content in any language can be translated into multiple Indian languages.

Some of the promising interventions are the following:

c. **Publishing software for educational material:** Teachers must be able to compile free content from one or more content repositories to devise interesting courses for which material can be shared with students in pdf form. Many older universities have printing divisions which can be used to print relatively inexpensive hard copies of educational material for students who would like to have them.

d. **Online assessments:** Assessments can be partly online multiple-choice examinations combined with projects and other hands on work that is evaluated separately by teachers. Some app-based multiple-choice examination systems are already available now that make it very easy for faculty to conduct quizzes.

19.5. Enhancing educational access

Appropriate use of ICT can help ensure that no student is left behind, by helping to reach students in remote areas, women, CWSN, students who have dropped out of schools, adults, and many others looking for lifelong education. However, it is critical that educational content for these purposes is developed keeping the specific requirements in mind.

P19.5.1. **Access to technology in remote areas:** School complexes must become the nodal agency for reaching out to the unreached. For this, they must be equipped with electricity, computers/ smart phones or other access devices, and Internet access else the promise of reaching the unreached will not be realised.

P19.5.2. **High quality specialised content to be made available in open educational repositories:** To ensure that all learners have access to high quality educational content, copyright-free educational resources including textbooks, reference books, videos (ideally with subtitles), teaching-learning materials, etc. will be created and curated from national and global sources at all levels of education and in multiple Indian languages, and made available in a single online digital repository e.g. the National Digital Library or NROER. This repository must be organised so that anyone can quickly and easily locate and download all relevant content. In order to reach the maximum number of students and teachers, distributing this content in any form for a nominal fee will be facilitated and encouraged.

P19.5.3. **Maintaining content quality:** It is critical to ensure that the repository in P19.5.2 remains a high quality and up-to-date resource so that it will be of value not only to teachers and students in the formal education system, but will also be a powerful enabler of lifelong learning. Hence a mechanism for creating and reviewing these learning resources will be devised (e.g. through online feedback on quality, relevance, and usefulness of content from users, both teachers and students, as well as competitions leading to national recognition for outstanding content creation). Thus, the platform will showcase the work of the best teachers, teaching in exemplary styles, across the country in every subject, level, and language. The platform itself (as in the case of all shared resources) once piloted and identified to be more widely usable by NETF, must be maintained by specialist organisations such as the CDAC or by private industry. The funding for this kind of professional maintenance of shared resources will be provided by the Central government.

P19.5.4. **Development of tools for automated language translation of educational content:** NRF will prioritise research and development of tools for automated and/or crowd-sourced language translation of educational content into all major Indian languages, so that additional content created in one language can be made rapidly available in other languages.

P19.5.5. **Specific technology related policy actions:** In terms of necessary interventions, software for adaptive learning for children of all ages with special needs must be prepared. Considerable research into pedagogy will be required for this purpose, and this can be funded by NRF at the Departments of Education in universities. Similarly, with intelligent tutoring systems, and many others.

The NRED will maintain all records related to institutions, teachers and students in digital form.

19.6. Streamlining educational planning and management

Arguably, the most important benefits from ICT are in the area of governance and management, where ICT tools can help with data-gathering and analysis, and record-keeping. ICT can also help in mainstreaming education by providing relatively simple and inexpensive solutions to problems that have plagued the sector for a long time, such as the problem of fake degrees among others.

P19.6.1. **National Repository of Educational Data:** ICTs will be fully leveraged for efficient and safe maintenance of educational information. All records related to institutions, teachers, and students will be maintained by a single agency in digital form in the NRED, which may be set up as part of the Digital India programme (see P6.1.5). NRED will be tasked with:

a. Developing appropriate systems for authorised institutional users to enter and update data. Teachers would be asked to enter data at most four times per year, in order to ease the significant burden on teachers in collecting, managing and transmitting data on an ongoing basis. This will be the only mechanism for institutions to disclose data to government agencies (both State and Central) for purposes of monitoring, accreditation, ranking, rating, and eligibility for government schemes.

b. Validating employment records of teachers and credits earned by learners (who will be, e.g. identified by their Aadhar numbers). This will simplify the process for learners and teachers seeking scholarships, employment, transfers between institutions, and re-entry into the education system. It will also minimise the manual effort in tracking details of students and teachers.

c. Complementing efforts to assess learning outcomes (e.g. NAS) by analyzing the performance of individual learners and institutions, and attempting to predict failures to meet outcomes so that proactive assistance measures can be undertaken.

d. Maintaining records while adhering to national norms, best-practices, and laws related to privacy of data. Practices based on "security by obscurity" will be explicitly rejected. This Policy further states that laws be strengthened to preserve the privacy of all individuals at the earliest.

e. Developing appropriate mechanisms to ensure the timeliness and reliability of data, so that policies can be based on high quality data. Current best practices employed by State and Central agencies can be studied and used as a baseline.

f. Alerting concerned governmental agencies about important trends (both positive and negative) as they are developing, for immediate action where necessary, and making these analyses public on an annual basis. These analyses will also include assessments of the quality of school education at the district level.

g. Monitoring migrant learners, and tracking their health and educational progress in order to mitigate the negative impact of disruptions to their well-being due to frequent displacement.

The National Repository of Educational Data will maintain all records related to institutions, teachers and students in digital form.

P19.6.2. **Technology for improving governance and administration:** Educational information management systems for community monitoring will be created and integrated with NRED. These systems will be used to streamline manual processes related to educational planning, admissions, attendance, assessments, etc. Local communities, panchayats, and SMCs will be able to look at the data and make sense of it themselves. ICT-based tools will be used immediately for all administrative tasks where they can improve efficiency and accuracy, including systems related to admissions, scholarships, assessments, counselling, placements, accreditation, etc. ICT will also be used for more efficient information dissemination and data gathering towards decision making. To facilitate information exchange between stakeholders, all educational institutions will provide all relevant stakeholders (students, parents, teachers, staff, etc.) with access to official institutional communication channels (e.g. institutional email).

P19.6.3. **Specific technology related policy actions:** Well over 30 years after the advent of email, many of our educational institutions do not offer institutional email to their faculty and students. The efficiency of communications that can be brought in through institutional email and list servers must be provided to all educational institutions without any further delay.

The problem of fake degrees can now be solved very elegantly by the new Blockchain technology. Each State government must commission its own depository of certificates, like the 'National Academic Depository', for all educational institutions within the States.

A considerable degree of computerisation of the administration and management of education has already taken place, with many aspects such as admissions, student records and even online assesment of examinations taking place in many universities in the State. These need to be scaled out to all educational institutions.

19.7. Disruptive technologies

Technology is increasingly disrupting multiple aspects of human society, including education. Some disruptive technologies will have clear applications to education, and methods to integrate such technologies into the education system through the involvement of the NETF have alredy been discussed. This section focuses on policies to address the broader consequences of disruptive technologies that are relevant to education, namely research, de-skilling, and awareness raising.

When the National Policy on Education 1986/1992 was formulated, it was difficult to predict the disruptive effect that the internet was about to have, particularly in boosting the development rates and impacts of other disruptive technologies. Our present education system's inability to cope with these rapid and disruptive changes places us (individually and nationally) at a perilous disadvantage in an increasingly competitive world. For instance, while computers have largely surpassed humans in leveraging factual and procedural knowledge, our education at all levels excessively burdens students with such knowledge at the expense of developing their higher order competencies.

This Policy comes at a time when the Fourth Industrial Revolution is already underway, and disruptive technologies such as artificial intelligence have emerged. At its core, artificial intelligence lowers the cost of prediction tasks that use existing data (such as, "This patient's symptoms") to fill information gaps (such as, "What disease does this patient have?"). As the cost of artificial intelligence based prediction falls, artificial intelligence will be able to match or outperform even skilled professionals such as doctors in certain predictive tasks and will therefore be a valuable aid to them in their work. Hence, artificial intelligence's disruptive potential is clear.

NITI Aayog recently produced a timely discussion paper entitled "National Strategy for Artificial Intelligence: #AIForAll", drawing on several prior investigations by MHRD and other national and international institutions, to identify challenges in leveraging artificial intelligence in India, and to articulate a national perspective and action agenda for artificial intelligence. This Policy broadly endorses the recommendations of NITI Aayog that pertain to education. It further notes that artificial intelligence provides an excellent example of how the Policy actions related to disruptive technologies can be applied to specific technologies. Thus, each of the Policy actions below is followed by comments on its application to artificial intelligence.

Other disruptive technologies such as Blockchain and Virtual Reality are just two of the many new technologies that are likely to have a sizeable impact on education.

P19.7.1. **Monitoring potentially disruptive technologies:** One of the permanent tasks of the Advisory Council of the RSA (see Chapter 23) will be to categorise emergent technologies based on their potential and estimated timeframe for disruption, and to periodically present this analysis to the RSA. Based on these inputs, the RSA will formally identify those technologies whose emergence

demands responses from the education system. Given the increasing pace of technological development, the traditional cycle of education policy revision may be too slow to respond to such disruptions. The Advisory Council of the RSA will propose technology-specific responses based on national and international perspectives, which will be refined in consultation with academia, industry and the wider public. These responses will be guided by the EC of the RSA. While some agility in the education system is necessary, the need for careful deliberation while assessing a specific technology's disruptive potential is well illustrated by artificial intelligence (which encompasses several distinct technologies). Decades ago, some experts viewed rule-based expert systems as an imminent disruptive artificial intelligence technology. Artificial intelligence's recent gains are in fact based on different techniques developed in the 1990s (multilayer neural networks with feedback) and were primarily triggered by recent advances in computation and the availability of large data-sets. NITI Aayog's discussion paper models one way in which the Advisory Council can propose technology-specific policy changes.

P19.7.2. **Research in disruptive technologies:** In response to the RSA's formal recognition of a new disruptive technology, the NRF will initiate or expand research efforts in appropriate areas including fundamental research in the domain, advancing the technology's development, and assessing the technology's socio-economic impact. For certain disruptive technologies, NRF may fund mega-projects with international collaborations.

In the context of artificial intelligence, the NRF may consider a three-pronged approach:

a) Advancing core artificial intelligence research,

b) Developing and deploying application-based research, and

c) Establishing international research efforts to address global challenges in areas such as healthcare, agriculture, and climate change using artificial intelligence.

P19.7.3. **Skilling and re-skilling:** The new institutional structure in higher education is well suited to skilling students and re-skilling the current workforce rapidly. Type 1 and Type 2 institutions will play an active role not only in conducting research on disruptive technologies, but also in creating initial versions of instructional materials and courses (including online courses) in cutting-edge domains and assessing their impact on specific areas such as professional education. Once the technology has attained a level of maturity, Type III institutions are ideally placed to scale these teaching and skilling efforts, which will include targeted training for job readiness. Disruptive technologies will make certain jobs redundant, and hence approaches to skilling and de-skilling that are both efficient and ensure quality will be of increasing importance to create and sustain employment. Institutions will have autonomy to approve institutional and non-institutional partners to deliver such training, which will be integrated with skills and higher education frameworks.

In the context of artificial intelligence, Type I and Type II institutions may offer PhD and Masters programmes in core areas (such as Machine Learning) as well as multidisciplinary fields ("artificial intelligence + X") and professional areas (healthcare, agriculture and law). They may also develop and disseminate authoritative courses in these areas via platforms such as SWAYAM. For rapid adoption, Type III institutions may initially blend these online courses with traditional teaching in undergraduate and vocational programmes. Type III institutions may also offer targeted training in low-expertise tasks for supporting the artificial intelligence value chain such as data annotation, image classification and speech transcription. In the context of Natural Language Processing (NLP), certain low-expertise tasks (such as translating simple sentences) may also be valuable from a pedagogical standpoint. Thus, efforts to teach languages to school students should be dovetailed with efforts to enhance NLP for India's diverse languages.

P19.7.4. **Raising awareness:** As disruptive technologies emerge, schooling and continuing education will assist in raising the general populace's awareness of their potential disruptive effects, and will also address related issues. This awareness is necessary to have informed public consent on matters related to these technologies. In school, the study of ethical issues (see Section 4.6.8) and current affairs (see Section 4.6.10) will include a discussion on disruptive technologies such as those identified by RSA. Appropriate instructional and discussion materials will also be prepared for continuing education.

Data is a key fuel for artificial intelligence based technologies, and it is critical to raise awareness on issues of privacy, laws and standards associated with data handling and data protection, etc. It is also necessary to highlight ethical issues surrounding the development and deployment of artificial intelligence based technologies. Education will play a key role in these efforts to raise awareness around these issues.